Understanding global warming in its historical and policy context

It is now over 100 years since Svante Arrhenius first warned about the risks of global warming and over 50 years since the evidence from Hawaii confirmed it to be occurring. After decades of denial, misinformation and inertia, all must now accept that global warming is real, urgent and may have very dangerous imminent consequences if not addressed.

This recognition and urgency has no doubt been prompted by the reality of extreme weather events, recent publications such as the Stern report and Al Gore's film, An Inconvenient Truth.

While we may be forced to accept this reality, there is still much valid concern about the very simplistic assumptions and models being promoted about what has caused global warming and what we need to do to address it. Assumptions and policy responses which dictate that:

1. Global warming is caused by an increase in the earth's greenhouse effect ...
2. due to increases in CO2 levels in the atmosphere ...
3. as a result of increased burning of fossil fuels by humans and, as such,
4. needs to be mitigated by 2100 by reducing CO2 levels and fossil fuel use ...
5. over the next decades to avoid adverse impacts projected by 2100.

While the above may have been a simple expedient message to manage public concern about global warming and provide the context for governments to talk about agreements and responses such as Kyoto, it may unfortunately be grossly misleading. It may not accurately reflect the complexity of the factors contributing to global warming, its cause, urgency and potential impact. In doing so it may impede scientific understanding of its real cause and more effective mitigation options. Indeed the status quo assumptions, models and expedient political responses to global warming that have been locked in for the past decades may now become the major risk factor in understanding the nature of the challenge and taking effective action, hopefully in time.

Systems analyses in reassessing scientific evidence and the current assumptions

To try to avoid these risks and provide an objective re-assessment of global warming a group of concerned independent scientists has sought to re-analyse all the known verified scientific evidence underpinning our current assumptions, models and understanding of global warming from a fresh systems perspective unimpeded by past positions. Rather than accepting the conventional physical climate models and assumptions, the analyses examined all relevant physical, chemical and biological evidence as well as skepticisms in a multi-factor pattern analysis. This sought to test many of the assumptions but also to identify novel inter-relationships and resolve inconsistencies that might contribute to a more ecologically coherent understanding of the causes of global warming and its mitigation options.

Although these systems analyses were based on verified scientific data, often identical with that underpinning the conventional climate models and assumptions, what was novel was the inconsistencies found between the models and some of this data and the profoundly different understanding of global warming that arose from this wider ecological systems analysis.

For example, the Vostok ice core data confirms there is a close association between CO2 levels and temperatures over a series of glacial and interglacial cycles over the past 420,000 years. However, it may not be valid to assume that such an association confirms the assumed causal relationship in which increases in CO2 levels cause increased temperatures. In fact temperature increases may precede CO2 increases by hundreds or thousands of years, indicating that some other factor may be triggering global warming and the CO2 increases.

Even more interesting is the consistent upper and lower CO2 and temperature levels in the

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Vostok data. This suggests that feedback mechanisms may be operating to control both CO2 and temperatures in successive glacial and interglacial cycles. It follows that this feedback mechanism may have governed the earth's temperature and CO2 levels, rather than the CO2 levels being the determinant factor as assumed in conventional climate models.

Most significantly this feedback mechanism appears to have failed in the current interglacial cycle resulting in CO2 concentrations increasing in the past 250 years well above previous maxima of 280 ppm to reach 382 ppm by 2006. Whatever caused the failure of this feedback mechanism that previously limited CO2 levels to below 280 ppm may be critical to understanding what caused global warming. Indeed the consequent CO2 increase may be a symptom of the failure of this feedback mechanism, not itself the cause of global warming.

Although there is no question that increased CO2 can contribute to global warming via its (minor) contribution to greenhouse heat absorption, it is critical in understanding the cause of global warming that we separate cause and effect. If, as the Vostok data indicates, the CO2 increases are a symptom of the breakdown of the former feedback processes, reducing the rate of CO2 emissions while slowing down symptom expression by itself, is unlikely to be effective in mitigating global warming. If we wish to mitigate global warming we need to restore the feedback process that formerly naturally controlled CO2 levels and temperatures in previous interglacials. To do that we first need to understand what these processes were and how to restore them.

Consequently the Vostok data fundamentally questions the validity of our simplistic assumptions about the causal relationship between increasing CO2 levels and global warming. Similarly it fundamentally questions the veracity of mitigating global warming by solely trying to slow down CO2 emissions. The Vostok data also indicates there may be a more effective way to mitigate global warming: by understanding and restoring the natural feedback processes whose failure in this current interglacial seems to have caused global warming. However to do this we may need to examine options beyond the conventional current climate models.

As another example, inconsistencies exist between current projections and research by NASA that confirms that the world's oceans initially absorb most of the CO2 emitted but that this is then equilibrated with the atmosphere over a 25-50 years lag period by which time 60% of the final CO2 level is expressed in the atmosphere. Much of the exponential increase in global CO2 emissions released since the 1970s is consequently still held in ocean biota and has not yet been fully equilibrated and expressed in the atmosphere. It follows that we are locked into an accelerating increase in atmospheric CO2 levels above the current level of 382 ppm over the coming decades irrespective of additional CO2 emissions or reductions from here on.

Consistent with the above, the rate with which CO2 levels are increasing has accelerated in the past decade to now average 2.5 ppm/an*. Consequently it is totally naïve to assume and irresponsible to promote that we can mitigate global warming by slowing down future rates of CO2 emissions by any level. We had that opportunity and warning in the 1970s but are now 25 years too late. We cannot avoid the lag effects and impacts from our past emissions by now slowing down future emissions.

So what levels of global warming and impacts have we already locked in? The Stern report tells us that while CO2 concentrations are currently at 382 ppm, when we add the greenhouse effect from methane, nitrous oxide and other greenhouse gases, they are already in effect at 430 ppm CO2 equivalence. The scientific consensus is clear that if CO2 equivalent levels increase above 550 ppm, the world risks dangerous climate change from average temperature increases ranging from 3-6 degrees celsius and even higher local temperature increases. Such temperature increases would risk triggering some of ten major positive feedback processes, such as

* Parts per million per annum

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the melting of polar ice caps and the thawing of permafrost, each of which could greatly intensify further dangerous uncontrollable climate impacts that risk the viability of current economic, social and ecological systems.

Unfortunately if, as we must, combine the data from the Stern report on the current CO2 equivalent levels and the NASA data on lag effects from CO2 emissions since 1970 it is inescapable that CO2 levels of around 550 ppm are already locked in and will occur as early as 2030. Irrespective of current talk and attempts to reduce future emissions we cannot escape temperature increases and rainfall disturbance accelerating further with these inevitably triggering uncontrolled dangerous climate change from as early as 2030, not a distant 2100 as hypothesised by some.

Looked at objectively the best available peer reviewed scientific evidence, and these analyses confirm that, using our current approaches:

1. We can no longer avoid the consequences of dangerous global warming.
2. We cannot mitigate these locked-in impacts by future CO2 emission reductions.
3. These dangerous consequences will occur as early as 2030 not 2100 as suggested.

Clearly this totally unpalatable situation is unavoidable if we stay with our current understanding and approaches. Our only hope is that our status quo understanding is wrong. Fortunately for us it is—fundamentally.

The basis of a biological understanding of global warming from the systems analyses

As indicated in the above analysis of the Vostok ice core data:

1. The CO2 increases may primarily be a symptom of, not the cause of, global warming.
2. This provides us with the option of addressing the real cause of global warming, not ineffectively and belatedly trying to slow down its symptom expression –providing we are prepared to think beyond the status quo dogma to understand the real causes and mitigation options.

The independent systems analysis of the available scientific evidence was undertaken specifically to provide this understanding and such mitigation options, hopefully in time. While there is always more detail to understand, the analyses already provide a consistent compelling case of what has actually caused global warming and what needs to be done to mitigate it. In view of the pending imminence of dangerous global warming consequences, it is important that this understanding and these mitigation options are now objectively analysed on their merits.

A detailed outline of the evidence and conclusions arising from this analysis was presented publicly at a Nature and Society Forum seminar in Canberra on 18 October 2006. Further detailed documentation is being prepared. This brief article cannot provide all the evidence and its substantiation. However it seeks to provide an overview of why the current assumptions and models of global warming are not sustainable and the basis for understanding the biology of global warming and its profitable mitigation.

If we look beyond the limitations of our current assumptions we in fact have a great depth of scientific knowledge about the earth and its climate. This knowledge logically needs to provide the context for re-examining our understanding of the earth's natural heat dynamics and balance and how these may have been disrupted by recent human activities to cause global warming.

Water and heat dynamics of global warming

Clearly the 'blue planet' for the past 4 billion of its 4.6 billion years has been unique amongst our sun's planets in that it has retained vast quantities of water which, because of water's unique chemical and heat absorptive and buffering capacities, have enabled the formation of a relatively stable climatic environment, compatible with life. In contrast to other nearby planets it is this water, with its unique heat buffering capabilities, that created the environment for the evolution of the initial marine life. This life in turn enabled the evolution of our current unique atmosphere and the maintenance of a stable buffered environment conducive to

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the evolution of other higher life forms.

Water and key biological processes have been fundamental in maintaining this buffered life-friendly environment through a range of balanced processes and effects including:

1. The formation of clouds of various densities with different albedos and effectiveness in reflecting from 0 to 90% (mean 30%) of the incident solar radiation back out to space.
2. The transfer of latent heat from the earth's surface for re-release in the troposphere through the evaporation and condensation of water fluxes.
3. The absorption of heat re-radiated from the earth's surface by water vapour and droplets in the lower atmosphere which constitutes from 60-80% of the greenhouse effect.

Collectively these three processes govern over 90% of the earth's heat dynamics and balance. These processes, particularly as manifest in the natural greenhouse effect, have enabled the earth to sustain relatively stable surface temperatures of around 18ºC for billions of years, some 30 degrees higher than they would be without the effect of the water and its dominant greenhouse role.

Biological processes in the earth's water, clouds and heat dynamics

Biological processes have been central over the past 3.8 billion years in creating and regulating these climatic conditions conducive to further biological evolution. These biological processes have operated substantially through the production of aerosols, microscopic biological nuclei that are fundamentally important in the condensation of water vapour into different cloud and rain droplets and, through their heat effects, the earth's climate.

Although many processes and agents regulate the global climate, the production of di-methyl sulphide by marine algae for the past 3.8 billion years has been fundamental in nucleating water vapour into micro-droplets which remain suspended and play a dominant role in the earth's natural greenhouse effect and climate stability.

Separate from such biochemical nuclei, terrestrial forests over the past 300 million years – but particularly over the past 100m years – have also been recorded to produce vast quantities of much larger bacterial cloud nuclei particularly in the former taxanomic group *Aerobacter aerogenes*. These bacteria are produced in the stomatal cavity of leaves and rise as part of the massive transfer of water and heat from the earth's surface as part of the transpiration flux. In contrast to the smaller micro-droplets formed by the biochemical nuclei, these bacterial nuclei are highly effective hygroscopic cloud and rain condensation nuclei, contributing significantly to the dense diurnal cloud dynamics and enhanced rainfalls particularly in tropical regions.

Whereas the biochemical nuclei often form light persistent clouds and hazes, the bacterial nuclei form dense cumulus and nimbus clouds with very high albedo effectiveness, reflecting up to 90% of incoming solar radiation back out to space (the global average is 31%). Because of these nuclei such clouds can significantly lower mean incident solar heating of the earth's surface by up to 25% below what it would have been under cloudless conditions. Combinations of such cloud albedo and latent heat flux effects have been measured to reduce surface temperatures in equatorial regions up to 15ºC relative to clear non-forested sites. Indeed a 1% increase in mean solar reflectance through increased cloud albedos may have an equivalent effect in cooling the earth's surface climate to that of reducing current CO2 levels back to pre-industrial levels, effectively negating the total global warming effect and risk.

It follows that the destruction of the large portion of the earth's forests that has occurred could have significantly reduced the transpiration of water and nuclei responsible for the maintenance of the earth's former dense cloud levels, albedos and thus heat dynamics resulting in global warming.

While the intensity of incoming solar radiation has increased steadily over the past four billion years with the expansion of the sun, it is significant that the earth's temperature and climate has stayed relatively constant and

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conducive to life. To maintain such a stable climate in a changing physical environment, biological processes may have contributed to initially capturing and retaining heat, as with the greenhouse effect initially enhanced by biological di-methyl sulphide production and subsequently through enhanced transpiration and nucleation of high albedo clouds via terrestrial forests which reflect and dissipate heat. It follows that the destruction of up to 80% of the earth's primary forests* by humans during industrialisation could have resulted in a marked loss of natural cooling capacity and therefore increased global warming, particularly as biological systems increasingly need to shade and cool the planet from incident solar radiation. Conversely the restoration of such natural forest systems and their cloud and albedo effects are likely to be highly effective in again providing the essential protective global cooling.

The potential significance and effectiveness of these heat dynamic processes can now be seen to dwarf the current attempts to reduce the greenhouse effect of CO2, even if this were possible in time and scale. Whereas water vapour constitutes some 60-80% of the natural greenhouse effect, by contrast CO2 levels represent some 20%. However as the net greenhouse effect represents only some 18% of the earth's net energy balance, it follows that the CO2 component of it may constitute less than 4% of the earth's heat balance. The 35% increase in CO2 levels since 1750 AD (from 280 to 382 ppm) may influence perhaps 1% of this overall heat balance. Seen in this context it is apparent that talk of slowing down CO2 emissions – for example through the Kyoto protocol – are at best insignificant and at worst a major deception and illusion in responsibly addressing imminent dangerous global warming.

Consequently water, for the past 4 billion years, has been and remains by far the dominant determinant of the earth's heat balance and climate and the critical means of mitigating global warming. Natural safe options exist for doing this that can also be highly profitable. As indicated a 1% increase in the average albedo reflectance of clouds would have a heat effect equivalent to reducing current CO2 levels back to pre-industrial, pre-global warming levels.

Why then have our climate models and assumptions about the causes of global warming ignored water and its heat dynamics as a possible causal and potential mitigating factor?

They have done this on the simplistic assumption that humans could not possibly have altered the earth's water cycles and, consequently, its heat dynamics to influence global warming. Based on this dogma they have simply assumed that the association between increased CO2 and temperatures in the ice core record is causally linked and that the CO2 emissions resulting from our recent use of fossil fuels must be causing global warming. This is despite full recognition that the increases in CO2 levels represented less than 0.002% of the earth's atmosphere by 1950 and can only have influenced less than 1% of the earth's heat balance.

Clearly the question then becomes how could humans have affected the earth's water dynamics to result in changes to the above heat balances so as to result in global warming? Could such changes explain the onset of global warming but also provide options for its mitigation? As detailed above the available scientific evidence clearly confirms that human activities can do so and, in fact, have done so.

Forests in the formation and albedo effect of clouds

Substantial de-forestation and farming of the Middle East, Europe, North Africa and North America prior to 1750 resulted not only in the release of vast quantities of CO2 into the atmosphere through the burning of timber and associated loss of soil organic matter but also the destruction of the carbon bio-sequestration of these forests. It is this degradation of global bio-sequestration capacities which appears to have removed the CO2 feedback control processes that the Vostok cores indicate had limited CO2 increases in previous interglacials and enabled the increase in atmospheric CO2 levels above 280 ppm from 1750. Although subsequent forest clearing, soil cultivation and

* Also known as old-growth forests

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fossil fuel use has added to and accentuated this CO2 increase, it is clear that the exponential increase in fossil fuel emissions since 1900 could not have caused the onset of the CO2 increases over 150 years previously.

Consequently deforestation can readily account for the increase in CO2 emissions, the degradation of bio-sequestration capacities and the observed increases in CO2 levels from 1750. However what evidence is there that deforestation has also affected regional and global water and heat dynamics leading to the subsequent observed warming of affected regions and climates?

Forests are responsible for the transpiration of vast quantities of water, both in quantity (representing some 48% of all terrestrial evapo-transpiration) but also from soil depths and over periods well beyond those from mere surface evaporation. This transfer of water from the earth's soils to the upper atmosphere by trees is both significantly greater than that observed from similar non-forested lands and contributes to far more frequent and denser cloud formation than from the similar non-forested lands. Consistent decreases in water loss, cloud formation and rainfalls have been recorded over regions following de-forestation. Higher level of cloudiness and rainfalls have similarly been confirmed over forested or re-forested regions than over equivalent cleared regions or oceans.

As outlined above, as part of their transpiring of vast quantities of water to form clouds, many forests also release vast quantities of bacteria. These are convected into the clouds from the stomatal cavities of foliage and act as cloud condensation and rainfall nuclei. Over 1 billion tonnes of such organic nuclei are produced and released into the upper atmosphere annually. Laboratory and cloud seeding studies confirm the effectiveness of these hygroscopic nuclei in forming condensation droplets, retaining and coalescing water droplets resulting in increased rainfalls. As a result many forested regions may be able to maintain higher levels of transpiration, cloud cover, cloud albedos, rainfalls and bio-productivities than cleared regions.

The increased water transpiration, density and frequency of cloud cover and albedo over such forested regions would naturally result in significantly greater reflectance of incident solar energy and cooling than over equivalent cleared regions without such cloud covers. Such forest and albedo effects can result in surface temperature in equatorial regions being as much as 15ºC lower relative to nearby cleared and non-clouded regions with similar incident solar radiation. As the CO2 concentrations are likely to be similar for both locations, such local and regional surface cooling effects must be entirely and directly associated with the changed water and cloud dynamics, not differences in CO2 levels.

Biological mitigation options

While representing only part of the substantial scientific evidence collected, the above analysis demonstrates that the widespread clearing of forests prior to 1750 could readily have:

- changed terrestrial water and heat dynamics
- lowered cloud and albedo reflectance and increased surface warming
- led to the observed increase in atmospheric CO2 levels
- prevented atmospheric CO2 being bio-sequestered as had occurred in previous interglacials due to human clearing of the forests and their ongoing human landuse.

Consequently and contrary to the assumptions in current climate models that humans could not have influenced the earth's water and hence heat dynamics, other than via CO2 emissions, there is in fact compelling evidence that this could have happened and it is totally consistent with historical fact and the scientific evidence of the causation of global warming.

Mitigation

In addition to providing a very simple, natural and logical understanding of global warming, the analyses also raise options for mitigating regional heat dynamics and the impact of global warming. Theoretically, if it is possible to enhance the natural cloud and albedo effects by 1%, it should be possible to offset temperature increases from the increased greenhouse

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effect resulting from the increase in CO2 levels since 1750. This could be done practically and profitably at collective, regional and catchment levels by restoring suitable natural bio-systems and water dynamics to generate the 1% increase in cloud albedos.

Most significantly the enhancement of such cloud albedos via the restoration of forest bio-systems and processes is totally risk free as it is entirely natural, simply involving the restoration of bio-systems and water and heat dynamics existing before 'civilisation'. However it is also uniquely powerful in enabling individuals, communities and regions to take affordable direct effective action to address regional climate mitigation and resilience buffering imperatives instead of being captive to policy inaction.

Just as the deforestation and soil degradation that caused global warming resulted in CO2 increases and the loss of bio-sequestration capacities, the restoration of such forests to mitigate global warming will of course involve – and benefit from – the bio-sequestration of atmospheric carbon into timber and soil organic matter. Apart from reducing the CO2 greenhouse component, the storage of carbon in soils will be highly synergistic in improving the structure, water infiltration and water holding capacity of the forest soils and the capacity of the forest to enhance and sustain transpiration levels. Similarly as more carbon is fixed in standing trees their capacity to transpire more water, produce more nuclei and provide a more shaded, resilient and cooler surface environment should all increase synergistically, directly helping to achieve the prime objective of mitigating global warming. Even though these mitigation strategies directly involve the bio-sequestration of carbon so as to improve water and heat dynamics and address the causes of global warming, the bio-sequestration of carbon needs to be seen as a means to this end, not the factor that in itself restores the heat balance.

Conclusions

The above outline has sought to provide a brief overview of the findings from the multifactor systems analyses undertaken to better understand the causes of and mitigation options for global warming. Although highly novel and challenging to the present conventional understanding and approaches the analyses show clearly that global warming:

1. is an extremely serious, imminent threat to global economies, societies and bio-systems unless addressed urgently,
2. cannot be explained through the current assumptions and climate models nor mitigated via current attempts at CO2 emission reductions,
3. can be mitigated only by addressing its real cause, not its symptoms.

Clearly further documentation needs to be provided to substantiate and confirm the scientific evidence underpinning these findings. This is being prepared. Analyses have similarly been conducted from a range of perspectives to test and confirm the veracity of the analysis and consistency of their conclusions. These have all reinforced the feasibility and validity of the above conclusions.

The above analyses provide a fundamentally new ecological but also a logical understanding of the causes of global warming and its mitigation options which is fully consistent with all the available scientific evidence. It effectively supersedes current assumptions and models of the causes and mitigation of global warming based on CO2. However, this does not mean that the current exponential release of CO2 from fossil fuels is not now a major contributing factor to global warming and its imminent dangerous consequences and need not be curtailed. It means simply that it is already too late to mitigate global warming through reducing its CO2 symptoms.

We now have no choice but to address global warming through its primary and initial cause. We need to rapidly re-establish natural cloud albedos and their cooling effects. To do this we need to re-establish the bio-systems that provided the transpiration and cloud nucleation processes on which such cloud albedos and cooling effects naturally depend. To help restore and support these bio-systems we need to bio-sequester carbon in forests but particularly soils so that they may enhance the natural infiltration

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and retention of availability soil water on which forest transpiration and cloud albedos depend. Consequently implementing a valid market price for carbon is likely to be the single most important factor in either impeding or enabling the restoration of these potentially critical but also highly profitable new forests.

With such policy incentives there may still be a sufficient, if brief, opportunity to mitigate the dangerous impacts of global warming by enhancing cloud albedos through the restoration of natural forest eco-systems and their water and heat dynamics.

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