Literature Review

Bushland and Urban Biodiversity Management in a Changing Climate:

a survey of published literature relating to climate change and management of biodiversity assets at a local government level in eastern suburban Melbourne.

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This literature review forms part of the project
"Bushland management and climate change:
Adapting management practices in response to landscape change"
as developed by the Eastern Alliance for Greenhouse Action.

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EAGA
EASTERN ALLIANCE FOR GREENHOUSE ACTION

Victorian Local Sustainability Accord

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Bushland and urban biodiversity management in a changing climate

Abstract

The Australian, Victorian and the majority of Victorian local governments accept that climate change is occurring and is influenced by human activity.

Temperatures will continue to increase for at least the next two decades due to inertia within the climate system.

Local government has roles in managing bushland and biodiversity, directly and indirectly. The Eastern Alliance for Greenhouse Action (EAGA) has identified the need to understand and adapt bushland and urban biodiversity management in the face of climate change. This project proposes to implement Stage one of a program to assist local government to better support species and ecosystems on public and private land to adapt to changes in climate.

Habitats and species have already begun to respond to the initial effects of a changing climate but most scientists agree that the current and expected rate of change is much greater than most natural systems will be able to keep pace with. Extreme events could have catastrophic consequences for regional biodiversity.

The details of "on the ground effects" of climate change are impossible to predict with confidence. Adaptive management strategies will need to be employed. As climate change impacts develop, it may not be possible to support some species where they historically occur.

If biodiversity is to have any prospect of adapting to climate change, landscape connectivity will need to be enhanced by management decisions and further fragmentation of the landscape avoided as proposed in the Victorian Climate Change White Paper.

To better support species and ecosystems to adapt to climate change, local government will have important roles advocating for appropriate policy, in mitigation of climate change and in adaptation to its inevitable effects.

Green spaces and biodiversity confer a number of benefits on local communities. Management will need to be responsive to the values the community places on those benefits. It will be necessary to identify, assess and prioritise those attributes to direct changes to bushland and urban biodiversity management and planning.

Climate scientists have described a number of feedback effects, which will reinforce climate change if they are triggered. If that occurs, self-sustaining 'runaway' climate change will follow and it will no longer be possible to stop this process.

The emissions trajectory which humanity will choose remains undecided. Current policies make it seem unlikely that we shall avoid the runaway trajectory and escape massive damaging changes.

Without global agreement on, and implementation of, urgent and effective action to reduce greenhouse emissions in the near future, massive biodiversity losses will be unavoidable.

It is essential for nations to act to mitigate the most extreme effects of climate change. There is ultimately no substitute for rapid and deep cuts in global emissions of greenhouse gases.

Introduction

Climate change, influenced by human activity, is real[1]. It is already affecting habitats and biodiversity in Victoria[2].

Local government has roles in managing bushland and biodiversity, directly and indirectly, to protect and preserve a number of attributes, which vary from council to council and site to site. In the future, these management roles will need to support adaptation to unavoidable climate change. Local government will also have roles in advocating for emissions reductions and reducing its own emissions while encouraging communities to reduce theirs.

The Eastern Alliance for Greenhouse Action (EAGA) consists of representatives from six eastern councils, (Boroondara, Knox, Maroondah, Monash, Whitehorse and Yarra Ranges). The councils are very diverse and have a range of issues to consider in very different landscapes.

EAGA identified the need to understand and adapt bushland and urban biodiversity management in the face of climate change and received funding from the Victorian Local Sustainability Accord.

This project proposes to implement Stage one of a program to assist local government to better support species and ecosystems on public and private land to adapt to changes in climate.

In order to understand the scale and nature of the problem the project proposes to:

- clearly scope and document the role of local government in bushland and urban biodiversity management;
- identify areas whereby local government can have the greatest positive influence over bushland and urban biodiversity management in response to climate change.

It is also important for local government, and other land managers such as local volunteer groups, to understand what changes they can expect as a result of climate change and adapt their management techniques.

A process to determine the impacts of climate change on biodiversity at a local level is critical to understand if changes to bushland and urban biodiversity management and planning are required.

This literature review is the first step in collating current relevant knowledge of expected climatic changes and the role of local government in bushland and urban biodiversity management. This information will be provide a context for workshops and further discussion leading to clarification and understanding of the issues which must be confronted if local government is to successfully

[1] CSIRO and the Australian Bureau of Meteorology, State of the Climate, March 2010
[2] Kearney, M.R., et al. Early emergence in a butterfly, Biology Letters 2010

adapt bushland and urban biodiversity management techniques in response to climate change.

Methods

In order to make the present study as comprehensive and current as possible, sources have not been limited to published peer-reviewed papers. A variety of sources has been utilised including peer-reviewed journals, government and agency reports which draw upon published papers and media reports which quote authoritative sources or contribute relevant information not otherwise available. Some documents have been obtained through personal communication.

Limitations

Given the rate at which new developments relevant to this study continue to be reported, it is anticipated that this literature review will be subject to refinement and amendment as the project progresses.

1.1 The global context

In his foreword to the United Nations Environment Program (UNEP) Climate Science Compendium[3], Ban Ki-moon, Secretary General of the United Nations, wrote:

> The science has become more irrevocable than ever: Climate change is happening. The evidence is all around us. And unless we act, we will see catastrophic consequences including rising sea-levels, droughts and famine, and the loss of up to a third of the world's plant and animal species. This report shows that climate change is accelerating at a much faster pace than was previously thought by scientists. New scientific evidence suggests important tipping points, leading to irreversible changes in major Earth systems and ecosystems, may already have been reached or even overtaken. This Climate Change Science Compendium is a wake-up call. The time for hesitation is over. We need the world to realize, once and for all, that the time to act is now and we must work together to address this monumental challenge. This is the moral challenge of our generation.

The science document referred to was an update of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which in 2007 had made it clear that there is near universal consensus that the average temperature of the Earth is increasing and it is "very likely" that this global warming, outside the range of natural variation, is due to the increase in the concentration of greenhouse gases in the atmosphere as a result of human activity. This conclusion was based primarily on a synthesis of published scientific literature, computer modelling of past and future climates, palaeoclimatic data and observed effects[4].

The scientific consensus had emerged in previous IPCC reports (1990, 1995 and 2001) but some policy-makers and media continued to assert the uncertainty of climate science and to claim that the apparent consensus was an artefact created by downplaying legitimate dissenting opinions. To test this hypothesis Naomi Oreskes analysed 928 abstracts published in refereed scientific journals between 1993 and 2003 listed with the keywords "climate change". None of the papers disagreed with the consensus position[5].

Since that time there has been ongoing worldwide research and the findings have been consistent with and have strengthened the consensus view[6]. Around the world a range of phenomena are being observed that are consistent with the predictions of climate scientists[7]. In the words of Professor Stephen Schneider, *"Nature has cooperated with theory"*[8].

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[3] McMullen, C.P. and Jabbour, J., UNEP, 2009
[4] Climate Change 2007: Synthesis Report, IPCC
[5] Oreskes, N., Beyond the Ivory Tower, Science 2004
[6] Romm, J., The year climate science caught up, Climate Progress, 4 January 2010
[7] McMullen, C.P. and Jabbour, J., UNEP, 2009
[8] Professor Stephen Schneider (Stanford University USA and IPCC), in a keynote address to the annual conference of the Climate Action Network Australia, 11th March 2009

Despite the increasing body of evidence consistent with mainstream climate science, attempts continue from certain quarters to discredit the research and the scientists[9]. These attempts usually appear to emanate from a few individuals and organizations that oppose effective action to mitigate climate change for ideological reasons or because they are perceived to be contrary to vested economic interests[10].

Recent attempts to question the credibility of climate science include accessing and releasing emails from researchers at the University of East Anglia Climatic Research Unit and the identification of two possible errors in the 2007 IPCC report. In spite of allegations of some inappropriate conduct by researchers and identification of some errors in detail, nothing has emerged that seriously challenges the consensus understanding of climate science[11,12,13,14].

An article that seeks to question some data widely used by climate scientists by showing that poor placement of surface measuring stations close to buildings had biased results in favour of warming has been published[15]. However a subsequent analysis comparing the results from appropriately sited stations to those from poorly sited stations found no evidence that temperature trends were inflated[16].

The scientific consensus noted in the IPCC reports remains robust.

Nevertheless, it is inherent in any comprehensive review process that there will be delay between the original publication of research and its final inclusion in the compiled reports. As a result, some articles included in the 2007 report (Assessment Report 4 or AR4) have been superseded by more recently published research and there have been many significant new advances in climate science since 2007. New knowledge has shown that climate change is tracking ahead of what had previously been expected[17]. Many researchers now consider the IPCC 2007 conclusions too conservative[18]. For these reasons an international scientific congress was held in Copenhagen in February 2009 and its findings were published as a Synthesis Report in June 2009[19].

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[9] Wilkinson, M., Crisis of climate change confidence challenged, The Age, 13 February 2010
[10] Owen J. and Bignell, P., Think-tanks take oil money and use it to fund climate deniers, The Independent 2010
[11] Cook, J., The IPCC's 2035 prediction about Himalayan glaciers, 21 January 2010
[12] Pachauri et al. IPCC statement on the melting of Himalayan glaciers, 20 January 2010.
[13] Netherlands Environmenal Assessment Agency, Correction wording flood risks for the Netherlands in IPCC report, 5th February 2010
[14] Reuters UK, U.N. climate panel admits Dutch sea level flaw, 13 February 2010
[15] Watts, A., *Is the U.S. Surface Temperature Record Reliable?* The Heartland Institute, Chicago, 2009
[16] Menne, M.J., Williams, C.N. and Palecki, M.A., On the reliability of the U.S. Surface Temperature Record, Journal of Geiophysical Research – Atmospheres, 2010
[17] Steffen, W., Climate Change 2009, Faster Change & More Serious Risks. May 2009
[18] UCL-Lancet, Managing the Health Effects of Climate Change, May 2009
[19] University of Copenhagen, Climate Change Global Risks, Challenges & Decisions, 2009

Other documents which compile recent research and assess current knowledge on climate change are the Copenhagen Diagnosis[20] and the Climate Change Science Compendium 2009[21]. The latter concludes,

> *"Evidence of unexpected rates of change in Arctic sea ice extent, ocean acidification, and species loss emphasizes the urgency needed to develop management strategies for addressing climate change."*

1.2 Projecting the future

While the understanding of climate science has improved in recent years it remains difficult to forecast in detail the extent of change into the future, primarily because successful mitigation is dependent on the effectiveness of human response through global international cooperation[22]. As noted by the World Meteorological Organization carbon dioxide, methane and nitrous oxide "have reached new highs in 2008"[23]. Both the Copenhagen Diagnosis[24] and the Victorian Government's white paper on land and biodiversity at a time of climate change[25] noted that the observed global CO_2 emissions from fossil fuel burning are tracking at or above the IPCC's highest scenarios. A report from the UK Met Office Hadley Centre[26] cautions that, *"There is a high probability that business as usual scenarios would push warming to 4°C this century, and in the worst case this could come as early as 2060".*

There remains no evidence that national governments are close to global agreement on stringent reductions[27].

The IPCC accommodates the ongoing absence of certainty on mitigation of emissions by considering an illustrative example from each of six groups of possible scenarios around four storylines based on projections of various combinations of differing levels of demographic, economic, technological and environmental developments[28]. Similarly, the authors of the biodiversity paper for the Garnaut Review[29] posit six scenarios, but these are based on differing levels of mitigation resulting in a range of combinations of temperature increase and changes in water availability.

The recently released report, Australia's Biodiversity and Climate Change[30] simplifies these approaches, adopting three emissions scenarios labelled "Recovery", "Stabilisation" and "Runaway". These are virtually indistinguishable until 2030. This is because there is a time lag of several decades in warming following any change in greenhouse gas

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[20] Allison, I. et al, The Copenhagen Diagnosis, 2009: UNSW CCRC
[21] McMullen and Jabbour, UNEP 2009
[22] Garnaut, The Garnaut Climate Change Review, 2008
[23] World Meteorological Organization, Bulletin No. 5, 23 November 2009
[24] Allison, I. et al, The Copenhagen Diagnosis, 2009: UNSW CCRC
[25] DSE, Securing Our Natural Future, November 2009
[26] Met Office, Science, Driving our response to climate change, December 2009
[27] Vidal et al., Copenhagen ends in failure, The Guardian, 19 December 2009
[28] IPCC, Working Group 1, Summary for Policy Makers, February 2007
[29] Australian Centre for Biodiversity, Monash University, Garnaut Review, June 2008
[30] Steffen W., et al., 2009, Australia's biodiversity and climate change

concentrations[31]. Therefore the thermal trajectory in the medium term (2030) is already determined and predictions on this time scale can be made with some confidence.

A further source of uncertainty in projections of future climate change is the existence of a number of reinforcing "climate feedbacks", through which climate change contributes to further change[32]. When climate change reaches a threshold beyond which the feedbacks are sufficient to maintain the process without further inputs a "tipping point" is reached and the climate enters a new state from which there is no way to recover[33]. Although there are both positive (reinforcing) and negative feedback effects the evidence, from observations as well as model projections, suggests that the positive feedbacks will dominate to amplify the disruption by humans of the climate system[34]. Exactly when tipping points may be reached is unclear but too many could be crossed this century because of the changing climate[35].

1.3 Climate Change in Australia

The high level of consensus around basic climate change science is reflected by informed scientific opinion in Australia. In its science policy document the Australian Institute of Physics states that, *"an increase in global temperature will adversely affect the Earth's climate patterns. The impact of these changes on biodiversity will fundamentally change the ecology of Earth*"[36].

Other societies and institutions that have adopted policy statements accepting the consensus view include The Federation of Australian Scientific and Technological Societies[37], the Geological Society of Australia[38], the Australian Meteorological and Oceanographic Society[39], the Australian Coral Reef Society[40], the Australian Medical Association[41] and the Institution of Engineers Australia[42].

The Australian Government established the Australian Greenhouse Office in 1998 and the Department of Climate Change after the change of government in 2007. Australia ratified the Kyoto protocol in 2008.

While the general effects of climate change can be projected on a global scale with a high degree of confidence, it is much more difficult to make more

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[31] McMullen, C.P. and Jabbour, J., UNEP, 2009
[32] Raupach, M. et al, Climate change poised to feed on itself, Sydney Morning Herald, 2009
[33] Ibid.
[34] Steffen, W., Climate Change 2009, Faster Change & More Serious Risks. May 2009
[35] McMullen, C.P. and Jabbour, J., UNEP, 2009
[36] http://www.aip.org.au/about.php
[37] http://www.fasts.org/images/policy-discussion/statement-climate-change.pdf
[38] http://www.gsa.org.au/pdfdocuments/management/GreenhouseGasEmissions&Climate Change_GSAPositionStatement_July2009.pdf
[39] http://www.amos.org.au/publications/cid/3/t/publications
[40] http://www.australiancoralreefsociety.org/pdf/chadwick605a.pdf
[41] http://www.ama.com.au/node/4442
[42] http://www.engineersaustralia.org.au/da/index/getfile/id/7396

detailed projections on a national, state or local scale. The level of confidence decreases as specificity increases[43]. Nevertheless CSIRO and the Bureau of Meteorology have produced indicative projections, such as Climate Change in Australia[44]. In this technical report the best estimate for warming over Australia by 2030 (relative to 1990) is approximately 1°C. By 2050 the expected range is an increase of 1.2°C – 2.2°C, depending on the emissions level scenario. This range increases to 1.8°C – 3.4°C by 2070. Corresponding changes in precipitation, an increase in occurrence of drought and a substantial likely increase in fire weather risk are projected.

In chapter six of his 2008 review[45] Professor Ross Garnaut provides a detailed summary of the projected Climate Change Impacts on Australia, describing the expected impact of growth in emissions on agriculture, infrastructure, biodiversity and ecosystems as *"severe and costly"*.

The findings of *Climate Change in Australia* and the Garnaut Review were based primarily on the state of the science as reflected in the IPCC's AR4. To bring understanding of the effects of climate change in Australia up to date, a review/synthesis of research published since 2007 with a particular focus on Australia has been prepared by Professor Will Steffen[46]. Among the *"many new developments and many significant new insights"* reported by Professor Steffen, one of the most important is that *"The climate system appears to be changing faster than earlier thought likely"*.

1.4 Climate Change projections for Victoria

As early as 1989 the Victorian government commissioned research into the effects of climate change in Victoria[47]. In 2004[48], and again in 2008[49], the state government published projections covering the regions of Victoria including Port Philip and Western Port Region. This contains most of the area covered by the Eastern Alliance for Greenhouse Action member councils (Text Box 1).

The Victorian State Premier, John Brumby, has stated in a Parliamentary debate, *"The weight of scientific evidence is overwhelming: increased concentrations of greenhouse gases due to human activity will produce significant global warming. Victoria is already warmer and drier as a result of climate change"* [50].

[43] IPCC, WG 1, FAQ 8.1 How reliable are the models? 2007
[44] Pearce, *Climate Change in Australia* (2007)
[45] The Garnaut Climate Change Review, 2008
[46] Steffen, W., Climate Change 2009, Faster Change & More Serious Risks. May 2009
[47] Pittock and Hennessy, CSIRO 1989
[48] Climate Change in Port Phillip and Westernport 2004
[49] Climate Change in Port Phillip and Westernport 2008
[50] Brumby, J., Parliamentary debate on taking action on climate change, 24 November 2009

Text Box 1- Summary of climate projections (Source: Climate Change in Port Phillip and Westernport, DSE 2008)

Climate change in the Port Phillip and Westernport region

By 2070 the region can expect to be:

- 1.3°C warmer with 6% less rain under a lower greenhouse gas emission growth scenario
- 2.6°C warmer with 11% less rain under a higher greenhouse gas emission growth scenario

Regional Snapshot

- **Hotter** – greatest increases in temperature are expected in summer
- **Drier** – greatest decreases in rainfall are expected in spring
- **Fewer rainy days** but increasing rainfall intensity
- By 2070, runoff into the Yarra, Maribyrnong, Werribee and Bunyip Rivers is expected to decrease by up to 50%

Additional reports focussing on the impacts of climate change on the region have been prepared for the Western Port Greenhouse Alliance (WPGA)[51,52]. The WPGA was established in June 2004 and covers four councils immediately south of the EAGA region, Cardinia, Casey, Frankston and Mornington Peninsula. While its reports contain useful material and recommendations, they are based on information from the 2007 IPCC Report.

In contrast, the recent report on Biodiversity and Climate Change prepared for the federal government[53], notes, "Carbon dioxide concentrations are rising even faster than previous projections, including those published by the Intergovernmental Panel on Climate Change (IPCC) in 2007".

According to the Victorian government white paper[54]

> Modelling indicates that the Victorian climate will be warmer and drier, particularly in northern Victoria. The latest projections from the CSIRO and the Bureau of Meteorology signal that climate change in Victoria will continue to manifest itself in a variety of ways. Change is likely to include:
> - more days over 35ºC
> - less annual rainfall, but more intense rainfall events
> - fewer frosts
> - more days with very high and extreme fire danger
> - more extreme weather events (floods and droughts).

In its 2007 Case Studies Report the MAV confirmed that, "Local government plays an important role in addressing climate change"[55]. In its submission to

[51] Brooke and Kinrade, 2006
[52] Kinrade and Justus, 2008
[53] Australia's Biodiversity and Climate Change: a strategic assessment 2009
[54] DSE, Securing Our Natural Future, November 2009

the Climate Change Green Paper[56], the association recorded that it had *"tested and consolidated a serious of viewpoints on climate change"* which it then used as the *"starting premise for its discussions"*, as follows:

The Victorian local government sector considers:

- *That climate change is happening, and that on a balance of probabilities, takes as its starting point the majority view of the Australian and international science communities that climate change as we are experiencing is influenced by human activity.*
- *That Australia is already experiencing change in the climate system and that this will only exacerbate over time as the global community is unlikely to be able to cut global greenhouse gas emissions sharply enough or fast enough for many future impacts to be avoided. Further, it is recognised that a level of warming is already 'locked in' to the climate system.*
- *That Australia as an already dry, hot nation will be amongst the most severely affected developed nations, and that the three levels of government with communities, will have to find ways to respond and adapt, such that communities remain viable.*
- *That there will always be uncertainty about the timing and magnitude of impacts as will affect any one region or municipality and that uncertainty cannot be used as an excuse for inaction.*

The MAV submission *"calls on the State Government to advocate to the Australian Government for a science-based target that reflects that true urgency of the climate change challenge and the need to avert 'dangerous climate change'."*

[55] MAV, Victorian Local Government, Greenhouse and Climate Change, Case Studies Report, 2007

[56] Municipal Association of Victoria (MAV), Submission, The Victorian Government Climate Change Green Paper, September 2009

2.1 Biodiversity and Climate Change

> Observed recent changes in climate, especially warmer regional temperatures, have already had significant impacts on biodiversity and ecosystems, including causing changes in species distributions, population sizes, the timing of reproduction or migration events, and an increase in the frequency of pest and disease outbreaks. By the end of the twenty-first century, climate change and its impacts may be the dominant direct driver of biodiversity loss and changes in ecosystem services globally [57].

The above conclusion from the Millennium Ecosystem Assessment was restated in his May 2007 International Biodiversity Day message[58] when Ahmed Djoghlaf noted that, *"Climate change is one of the major driving forces behind the unprecedented loss of biodiversity."*

In a 2008 discussion starter the Municipal Association of Victoria characterized the predicted effects of climate change in Victoria as *"overwhelmingly negative"* [59]*.* These effects included *"Mass species extinction and ecosystem collapse."*

Changes to biodiversity caused by climate change are already evident, including genetic shifts, changed migration patterns in some birds, altered lifecycles, reduced reproduction rates, expansion of some vegetation types at the expense of others and changing fire regimes in southern Australia[60].

The Victorian Climate Change White Paper[61] explains,

> *Climate change is expected to influence the composition of ecosystems and the spatial distribution and abundance of species and communities. Likely impacts will include changes to:*
> - *water flows in rivers and wetlands*
> - *groundwater recharge*
> - *dryland and estuarine salinity levels*
> - *fire intensity and frequency*
> - *weed and pest distribution*
> - *timing of pollination and flowering*
>
> *This suggests that the drought/fire/flood cycle that plays a large part in determining Victorian environments will be intensified. Ecosystems will change as a result, although it is impossible to predict exactly how. The changes will affect our biodiversity as some plants and animals will not be able to adapt to the altered conditions. Some localised extinctions may occur. Landscapes and natural environments will change as biodiversity self adjusts.*

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[57] Millennium Ecosystem Assessment, 2005
[58] Djoghlaf, A., 2007, Message
[59] Municipal Association of Victoria (MAV), Discussion Starter: MAV Environment Policy Forum – Climate Change, 2 October 2008
[60] Steffen W., et al., Australia's biodiversity and climate change, 2009
[61] DSE, Securing Our Natural Future, November 2009

Science is indicating a hotter, drier climate is already impacting on Victorian species. Recent research shows a marked collapse in bird numbers and breeding events due to the lack of water in the landscape. This is affecting food sources for many birds, such as species that rely on the nectar of flowering gums.

The projected impact of a warmer climate on a Victorian species has now been confirmed by research. One of the first studies, and the first in Australia, to link changes in a natural system to regional climate change due to greenhouse gases in the atmosphere[62] shows that the common brown butterfly in the vicinity of Melbourne now emerges from its cocoon ten days earlier than it did sixty-five years ago[63].

In a systematic review of the scholarly literature, Heller and Zavaleta[64] analysed the recommendations for biodiversity management given in 113 published papers. They then ranked the recommendations by frequency and found that four consistent broad themes emerged:

(1) the need for regional institutional coordination for reserve planning and management and to improve landscape connectivity;
(2) the need to broaden spatial and temporal perspective in management activities and practice, and to employ actions that build system resilience;
(3) the need to incorporate climate change into all conservation planning and actions, which will require increased research and capacity to forecast future conditions and species responses and to deal effectively with unavoidable uncertainty; and
(4) the need to address multiple threats and global change drivers simultaneously and in ways that are responsive to and inclusive of diverse human communities and cultures.

Similar themes had emerged in an earlier paper by Harry Clarke[65], which considered public policies to reduce the impact of climate change on the range and richness of Australian biodiversity. Both papers identified a need for adaptive policy development which would accommodate ongoing changes in knowledge and circumstances.

In a 2006 article Wilby and Perry[66] reviewed the range of climate-related threats to biodiversity in the aquatic, intertidal and terrestrial habitats of urban areas using London as a case study. Wilby and Perry illustrated potential impacts, and contend that 'green spaces' in cities could be used by planners to counter climate-related threats to biodiversity, as well as to improve flood control and air quality, and reduce urban heat island effects. They warn, *"that climate change might not affect urban ecosystems in the same way as their*

[62] Phillips, N., Butterflies offer climate warning, The Age, 18 March 2010
[63] Kearney, M.R., et al. Early emergence in a butterfly, Biology Letters 2010
[64] Heller, N.E. & Zavaleta, E.S., 2008, Biodiversity Management
[65] Clarke, H.,2007, Conserving Biodiversity
[66] Wilby and Perry, 2006, Climate change, biodiversity and the urban environment

non-urban counterparts, and hence studies conducted in 'natural' systems may not easily translate to urban environments".

One specific effect reported by Wilby and Perry is that modifications to river flow regimes, water temperature and water quality can impact the survival, spawning times, reproductive success and growth of invertebrates, freshwater fish and amphibians. This effect has also been noted in Melbourne's waterways[67].

In a review of media weather reports over the past decade Standley *et al*. surveyed the impacts of weather on service provision in London over the past decade[68]. They recorded weather impacts on green spaces and wildlife through heat, drought, floods and fire.

For his Climate Change Review, Professor Ross Garnaut commissioned a paper on Biodiversity and climate change[69]. In this paper it is pointed out that, *"Proactive investments now will be much more effective and more economical than delaying responses to climate-change effects. The following actions will improve the nation's capacity to buffer our biodiversity against climate change:*

- *Broad-scale restoration of native vegetation through strategic actions such as 'biolinks'*
- *Restitution of substantial amounts of water to natural ecosystems, including sympathetic management of riparian zones*
- *Reduce and avoid 'over-engineering' and 'over-management' of all natural biological resources".*

According to Dunlop and Brown it is impossible to prevent changes to species and ecosystems under climate change; managers will need to choose more actively what change is acceptable and what aspects of biodiversity should not be lost[70]. They say, "Ultimately it is a societal issue to decide what changes are and are not desirable, and it will probably require extensive community debate informed by different scientific perspectives on what changes might occur".

Major conservation policy issues for Biodiversity in Oceania are considered in a recent paper by Kingsford *et al*.[71]. Following a review of the literature they identified six major threatening processes,

- habitat loss and degradation,
- invasive species,
- climate change,
- overexploitation,
- pollution, and
- disease.

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[67] Fonseca, A., Volunteer frog finders hop in to help, The Age, 5 October 2009
[68] Standley et al., (2009), Wild weather warning
[69] Australian Centre for Biodiversity, Monash University, Garnaut Review, June 2008
[70] Dunlop, M. & Brown, P.R.,Implications of climate change, 2008
[71] Kingsford, R.T., et al., 2009, Major Conservation Policy Issues for Biodiversity in Oceania

For each threatening process, Kingsford et al. propose a set of conservation policies. Under *"Climate Change"* these policy recommendations are -

1. Reduce global greenhouse gas emissions.
2. Identify, assess, and protect important climate refugia (ecological and evolutionary).
3. Ameliorate the impacts of climate change through strategic management of other threatening processes.
4. Develop strategic plans for priority translocations and implement when needed.

Steffen at al. (2009)[72] agree that translocation may need to be considered for species whose historical locations become increasingly marginal under climate change. Other studies proposing consideration of interventions such as translocation, captive breeding and propagation including Wilby and Perry (2006)[73] and McMullen and Jabbour(2009)[74]. However Dunlop and Brown (2008) caution that translocation may be expensive, intensive, has low success and frequently has unforseen negative consequences, though it may become "the only option" for some species[75].

In March 2009 WWF released a report[76] considering the impact of climate change on some of the world's best-known organisms including kangaroos and coral reefs. A similar report from the IUCN's Species Survival Commission released in December 2009[77] included a section on koalas, citing increasing risks from drought, bushfire and malnutrition due to reduced protein content of eucalyptus leaves. This last effect is cited as, *"one of the very few examples in which the direct effects of CO_2 can be linked to populations of wild mammals".*

The Great Barrier Reef is one of Australia's World Heritage Properties and the impacts upon it of climate change are considered in a preliminary assessment report, previously cited[78].

The future of the Great Barrier Reef is discussed in detail in a report for the Marine Park Authority[79]. The report concludes that, *"the overall outlook for the Great Barrier Reef is poor and catastrophic damage to the ecosystem may not be averted. Ultimately, if changes in the world's climate become too severe, no management actions will be able to climate-proof the Great Barrier Reef ecosystem."*

Similar conclusions are drawn in a more wide-ranging report on the vulnerability of Australia's biodiversity[80]. In order to maintain biodiversity in a

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[72] Steffen W., et al., Australia's biodiversity and climate change, 2009
[73] Wilby and Perry, 2006, Climate change, biodiversity and the urban environment
[74] McMullen and Jabbour, UNEP 2009
[75] Dunlop, M. & Brown, P.R.,Implications of climate change, 2008
[76] Matson, T., 2009, Climate Change and Species
[77] IUCN Red List, Species and Climate Change, More than just the Polar Bear, 2009
[78] ANU 2009, Implications of Climate Change
[79] Great Barrier Reef outlook report 2009 / Great Barrier Reef Marine Park Authority.
[80] Steffen W., et al., Australia's biodiversity and climate change, 2009

changing climate the report proposes building resilience by maintaining well-functioning ecosystems, protecting a representative array of ecosystems, removing or minimizing stressors, building connectivity and identifying and protecting refugia.

Changes to management and policy need to be implemented. Five key issues for policymakers are identified in Steffen et al. These are:

- We need to adapt and reform the way we manage biodiversity to meet existing and new threats;
- There should be a national process to agree upon a new national vision for, and approval of, biodiversity management;
- We need to renew public and private investment in our natural environment (our life support system);
- We need to build agile and innovative governance arrangements for biodiversity conservation;
- Strong emissions mitigation action globally and in Australia is vital to stay within the capacity of biodiversity to adapt.

With respect to the issue of emissions reduction, Steffen et al. warn that, *"If the current trajectories continue we are headed for significant changes – a mass extinction event equivalent to those of the distant past; in fact, the sixth great extinction event in the Earth's history. It took millions of years for biodiversity to recover from these past massive extinction events".*

This is what Steffen et al. describe as *"the runaway scenario"*, on which we are currently tracking. Under a runaway climate scenario there are no promising and cost-effective approaches for conserving our vulnerable natural ecosystems.Their report concludes, *"There is ultimately no substitute for rapid and deep cuts in global emissions of greenhouse gases"*.

In September 2009 forty leading scientists published a statement that to *"maintain a credible ambition of avoiding dangerous climate change"*, world leaders must cut greenhouse gas emissions by *"at least 40% below 1990 levels by 2020"*[81].

At the present time, following the Copenhagen conference in December 2009, global agreement on this course of action does not appear likely[82].

2.2 Climate Change, Biodiversity and Fire

The potential for increased risk of catastrophic bushfires in Victoria resulting from a changing climate has been acknowledged for at least the past two decades. As early as 1989 the Victorian government was warned of the danger in a report for the EPA, which stated, *"It should be noted that a number of practical consequences, such as … increases in degree-days, …*

[81] Hoegh-Guldberg et al. Scientists' statement
[82] Carrington, D. et al., Global deal on climate change in 2010 'all but impossible', The Guardian, 1 February 2010

and possibly increases in fire risk and episodic summer aridity, will occur ..." [83]

In its 2007 report the IPCC stated, *"An increase in fire danger in Australia is likely to be associated with a reduced interval between fires, increased fire intensity, a decrease in fire extinguishments and faster fire spread. In south-east Australia, the frequency of very high and extreme fire danger days is likely to rise 4-25% by 2020 and 15-70% by 2050"* [84].

Releasing his 2007 report[85], researcher Dr Chris Lucas said bushfire seasons in recent years had exceeded predictions for 2050 with extreme fires such as those in Victoria in 2002-03 and 2006-7 possibly providing an indication of fire danger for the future. *"Over the last five or six years, we've been seeing this increase in fire danger, and seasons like last year's are going to keep occurring,"* he said[86].

In his 2008 report[87], Ian McPhail, the Victorian Commissioner for Environmental Sustainability, warned -

Climate change is affecting us already. Victoria has warmed by 0.6°C since the 1950s. Six out of the ten hottest years on record in Victoria have occurred since1990, with 2007 being the hottest year of all. Rainfall during the last ten years has also been much lower than the historical long-term average. Climate change projections for Victoria include:

- *higher temperatures of 0.6°C to 1.2°C by 2030*
- *very high or extreme fire danger days across south-eastern Australia expected to increase by up to 25% by 2020 and up to 230% by 2050.*

In a commentary on the 'Black Saturday' fires, published on 16th February 2009[88], Professor David Karoly, leaves no room for doubt, *"it is clear that climate change is increasing the likelihood of environmental conditions associated with extreme fire danger in south-east Australia".*

The connection between climate change and increased risk of extreme bushfires has been noted globally[89] and is well accepted amongst informed scientists and commentators[90].

Such a rapid and dramatic change in the fire regimes of ecosystems will clearly have direct, short and long-term impacts on biodiversity. A study by Bradstock *et al*.[91] reported. *"a negative relationship between high frequency fire and floristic diversity"*.

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[83] Pittock and Hennessy, 1989, Regional Impact of the Greenhouse Effect in Victoria
[84] Climate Change 2007**,** IPCC Working Group II
[85] Lucas, 2007, Bushfire Weather in Southeast Australia
[86] *The Australian*, 27 September 2007
[87] McPhail, I., 2008, State of the Environment Victoria 2008 Summary
[88] Karoly, D., 2009, Bushfires and extreme heat in south-east Australia
http://www.realclimate.org/index.php/archives/2009/02/bushfires-and-climate/
[89] Almagro, C., 2009, En futuro en llamas, Greenpeace (Spain)
[90] ABC News, Scientists discuss climate change, bushfire link, ABC, 27 January 2010
[91] Bradstock et al., 1998, Bushfire risk at the urban interface

But there are also indirect effects. Since the catastrophic fires of February 2009 some politicians and sectors of the public have demanded changes in the management of urban bushland, especially the urban/forest interface. Such changes have already been seen in calls for increased areas of fuel reduction burning and the adoption of the 10/30 policy[92, 93], allowing clearing of vegetation around homes without a permit. A similar policy has also been adopted requiring removal of trees within 15 metres (and assessment of those within 40 m) of designated fire refuges at some schools[94].

Finding a way to manage bushland and reserves to maintain biodiversity while at the same time minimizing hazards to communities will be an increasing challenge for land managers, including local governments.

3. Local Government and Community Engagement

> Parks deliver many benefits to Australians and New Zealanders now; their importance will only increase with time as the stresses of urbanisation, population growth, climate change and resource depletion impact on our societies. It is our responsibility to ensure the ongoing protection and good management of parks for present and future generations to enjoy and cherish[95].

This is the closing paragraph of the foreword by John Landy, to a report on The Value of Parks[96]. Among the benefits of urban parks listed in the report are:

- Many city parks conserve dwindling urban biodiversity,
- Trees filter the air by stabilising dust and absorbing pollutants,
- Green spaces in urban areas bring a cooling effect,
- Urban parks are places for sport and exercise, improving physical health and enhancing mental health and wellbeing,
- Urban parks are used by local communities for promotional, recreational and multicultural activities and as meeting and gathering places,
- Opportunities to volunteer and participate in park management,
- Proximity and park views increase residential property values,

The report states that, “We need to extend our parks in cities and towns, on the urban periphery, and across the landscape. Our urban landscapes need plentiful and varied parks and green space connected by more cycling and walking trails.”

The health and other benefits of parks are further explored in a literature review by Deakin University, which also notes “multiple benefits” of urban

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[92] Making Victoria Fire Ready, 2009, Victorian Government DSE
[93] Fyffe, M., Expert warns of land clearing risks, The Age, 27 September 2009
[94] Munro, I., School baulks at fire refuge tree clearing, The Age, 18 September 2009
[95] Landy, J., Foreword, The Value of Parks, Parks Forum 2008
[96] Leaman, G., Figgis, P. and Holliday, J., The Value of Parks, Parks Forum, 2008

parks[97]. The review calls on government departments planners and park management bodies to facilitate, "the engagement of the community".

A similar conclusion was reached by Renae Stenhouse in her 2001 article[98] which analysed the results of a questionnaire addressing threats to bushlands, management methods used, perceived effectiveness of management, problems faced and the interaction between community groups and local government. Stenhouse concluded that, *"Better partnerships must be built between community groups and local government, to improve the process of management of locally significant bushland"*. Although weed infestation and fire were listed as main threats, climate change was not mentioned. Leaman et al. also stress the importance of good fire management and weed control practices[99].

The report for the Victorian government by Fritze et al.[100] takes a broad view and mentions the contribution of Landcare groups to planning and carrying out projects aiming to restore and improve farmlands, coast, waterways, urban environment, revegetation and wildlife habitats.

The need to identify climate change adaptation actions that are applicable to Australia's climatic conditions and climate impact risks and that can be implemented by Australian local governments led to the publication by the Department of Climate Change of a report in 2007, updated in 2009[101]. The report points out the dual responsibilities of local governments for both mitigation and adaptation actions to be conducted simultaneously. In the report a number of possible adaptation actions are listed and briefly evaluated. Adaptation Actions for Natural Resource Management (as given in Table 8 of the report) include -

<u>Biodiversity management and protection</u>

- Develop a Local Biodiversity plan as a component of the local planning strategy and town planning scheme.
- Implement conservation management plans for local reserves and other local government lands.
- Encourage private land conservation, e.g. through incentives.
- During strategic spatial planning, take into account impact of potential reduced water supply on urban vegetation. trees can result in subsidence risks and location of water bodies relative to urban vegetation may help sustain the vegetation.
- Continue to develop roadsides/utility corridors as native vegetation corridors, in consultation with relevant road authorities to ensure road use safety is protected.

<u>Land/park management</u>

- Take into account the areas at increased risk of bushfire from climate

[97] Maller, C. et al., Healthy parks, healthy people, Deakin University, 2008
[98] Stenhouse, R., 2001, Management of urban remnant bushlands
[99] Leaman, G., Figgis, P. and Holliday, J., The Value of Parks, Parks Forum, 2008
[100] Fritze et al., 2009, Community Engagement and Climate Change
[101] SMEC Australia, Climate Change Adaptation Actions for Local Government 2009

change in the use of prescribed fire as a tool for managing fuel accumulation (recognising that inappropriate fire regimes can potentially threaten the conservation of biodiversity).
- Use of fire adapted vegetation (much of Australian vegetation is fire adapted).
- Ensure that 'fire management zones' have been identified.
- Ensure that clear objectives and the most suitable forms of fire management and mitigation for each zone have been developed, e.g. identification of assets and collation of information on how fire, and fire mitigation, might affect these assets. (note – many local governments have already done this)

Pest/weed management

- Develop and implement a pest, weed and invasive species management policy/ strategy that takes into account changed climatic conditions (many local government areas have management policies/ strategies in place).
- Promote awareness to local communities of potential weed risks resulting from climate change in the local area (incorporate into existing awareness programs if appropriate).
- Revisions to mowing and weed control schedules to take into account changed climatic conditions that affect growth and dispersion.

The Cities for Climate Protection Measures Evaluation Report[102] documents a wide range of actions being taken by councils to reduce emissions from their buildings, street lighting, vehicle fleets, waste, and water and sewage operations. These actions resulted in emission reductions of almost 649,000 tonnes CO2-e in 2007/08, and over 3.5 million tonnes CO2-e since reporting began in 1998/99. The resulting reduction in energy use saved councils at least $8.3 million in 2007/08, and more than $41 million since 1998/99. In addition the report states that, "Councils are increasingly assisting residents and local businesses to reduce community emissions from energy use, transport and waste through a wide variety of projects that focus on implementation, education, and behaviour change. Overall, these actions were estimated to have saved 4.1 million tonnes CO2-e".

The report contains nine case studies, briefly describing several innovative projects. It also includes short profiles of councils, including Boroondara, Knox and Whitehorse, and a summary of some of their actions.

The May 2009 paper by Maddocks' Sustainability & Climate Change Team[103] focuses on the consequences of climate change for planners, responses in state and local government planning schemes and liability exposure. Like the authors of the SMEC report they state that the various physical effects of climate change are relevant for planners in respect both of necessary *"adaptation"* and involvement in *"mitigation"* efforts to reduce Australia's emissions. The paper states that, *"Perhaps the biggest threat that*

[102] ICLEI, 2008, CCP Local Government Action on Climate Change
[103] Maddocks, 2009, Implications of Climate Change for Planning

climate change poses for local governments, including planning authorities, is the risk of being held liable for:

- *Failing to safeguard against climate change impacts in planning and development decisions – in other words, failing to facilitate adaptation to climate change.*
- *Failing to take into account an activity's contribution to climate change in planning, development decisions and other activities – in other words, failing to mitigate the effects of climate change."*

The Victorian white paper[104] lists the current natural resource management roles and responsibilities of Local Government Authorities as

- Advocate and promote proposals which will benefit the local community.
- Plan for and provide services and facilities for the local community.
- Provide and maintain community infrastructure in the municipal district.
- Undertake strategic and land use planning for the municipal district including:
  - Planning for sustainability in nature conservation, energy use and community involvement.
- Administrator Victorian Planning Provisions.

Local government policy statements seeking to address the impacts of climate change include those of Byron Bay[105] and the Shire of Yarra Ranges[106].

It is noted that under the Victorian Government's framework for action, as articulated in the white paper[107], the Central Highlands is nominated as a *"Flagship Area"* to be managed for, *"the protection and enhancement of the natural assets within them focussing on the ecosystem services they provide"*. A significant part of this area is within the Shire of Yarra Ranges. Another element of the framework is the establishment of *"biolinks"* to increase ecological function and connectivity. It is anticipated that road reserves and river frontages will be important elements.

[104] DSE, Securing Our Natural Future, November 2009
[105] Byron Bay Shire Council, 2009, Climate Change Strategic Planning Policy (Draft)
[106] Shire of Yarra Ranges, 2008, Environmental Initiatives Update 08
[107] DSE, Securing Our Natural Future, November 2009

4. The Urban Heat Island effect

Urban Heat Islands occur when human development causes a reduction in evapo-transpiration, which normally has a cooling effect. Materials used in buildings and hard surfaces which absorb and re-emit heat, reduction in shading vegetation, inhibition by buildings of air movement, human activities such as artificial heating and vehicle engines and smog all increase the impact.

Climate change is expected to increase the occurrence of urban heat island events— air temperatures in cities will rise disproportionately to surrounding areas and result in locally acute adverse human health, economic and environmental impacts[108].

Local mitigation of this effect by appropriate management of urban green space may therefore become increasingly important to local government. The cooling effect of some parks and reserves may become a priority attribute for which they are preserved and managed[109].

Knowledge of Urban Heat Island Effects has been surveyed in a report for Knox Council[110]. The report cites a *"measured difference in average temperature from Melbourne City to Narre Warren of approximately 4 degrees Celsius primarily due to UHI impacts"*. It also discusses the roles of vegetation and water sensitive urban design (WSUD) in reducing the urban heat island effect.

Reductions in natural vegetation (forest and grass) and water area (such as wetland and lake) would change microclimate patterns of temperature and make the environment more fragile and climate elements more sensitive to global temperature change[111]. Relationships between temperature and vegetation cover have been demonstrated in the growing city of Gaberone, Botswana[112].

The urban heat island effect is responsible for temperature differences of up to 7^{o}C between cities and the country in the United Kingdom[113]. The majority of heat-related human fatalities during the European summer of 2003 were in urban areas[114]. In Victoria around 374 deaths have been attributed to the heatwave in January and February 2009[115]. This means that the cooling of the urban environment is a high priority for urban planners and designers[116]. Proven ways of doing this include altering the urban microclimate by

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[108] Corburn, J., Cities, Climate Change and Urban Heat Island Mitigation, 2009
[109] Coutts, A.M., Beringer, J., Tapper, N.J., Changing urban climate and CO_2 emissions, 2008
[110] Noyce, M., Analysis of Heat Island Effects, 2009
[111] He, J.F., et al., Assessing the effect of land use change, 2007
[112] Jonsson, P., Vegetation as an urban climate control, 2004
[113] Smith, C. and Levermore, G., Designing urban spaces, 2008
[114] ibid.
[115] Cooper, M., Death toll soared during Victoria's heatwave, The Age, 6 April 2009
[116] Smith, C. and Levermore, G., Designing urban spaces, 2008

modifying its heat absorption and emission, for example through urban greening, the use of high-reflectivity materials, and by increasing openness to allow cooling winds[117].

The Co-operative Research Centre for Irrigation Futures estimates that trees, shrubs, lawns and wall gardens can lower temperatures by 2-8 degrees because increases in evapo-transpiration reduce building energy use by 7-47 per cent[118].

In a warming and drying climate it will therefore become increasingly important for the cooling effects of urban parklands to be recognised and where necessary protected through appropriate management strategies.

[117] ibid.
[118] Fisher, P., It's time literally to go green, The Age, 23 January 2009

6. Conclusion

As documented in the publications reviewed, the Australian and Victorian governments and the majority of the Victorian local government sector accept the scientific consensus that climate change is occurring and is influenced by human activity. Globally, the effects are being documented to be occurring earlier and more severely than previously expected. In Victoria a number of extreme weather events including extended drought, heat waves, extreme fire weather, high overnight minimum temperatures and violent storms have occurred in the past decade, consistent with climate change projections.

The literature advises that, whatever decisions are taken, temperatures will continue to increase for at least the next two decades due to inertia within the climate system.

Habitats and species have already begun to respond to the initial effects of a changing climate but most scientists agree that the current and expected rate of change is much greater than most natural systems will be able to keep pace with. There will also be increasing danger of extreme weather events including bushfires and floods. Extreme events can result in sudden 'non-linear' changes in the environment and a single such event, or a series of events, could have catastrophic consequences for regional biodiversity.

Assuming that the global community does ultimately agree to limit emissions to safe, or at least tolerable, levels, the details of "on the ground effects" of climate change at site and species level are impossible to predict with confidence. There will be "surprises". Adaptive management strategies will need to be employed, that can be constantly monitored, evaluated for effectiveness and revised as necessary. As climate change impacts develop, it may not be possible to support some species where they historically occur. Management intervention, such as priority translocations and captive breeding, may be required.

As agreed by Heller et al., Clarke and Garnaut, if biodiversity is to have any prospect of adapting to climate change, landscape connectivity will need to be enhanced by management decisions and further fragmentation of the landscape avoided. This is reflected in the recommendations of the Victorian Climate Change White Paper, which proposes "Flagship" areas connected by biolinks.

To better support species and ecosystems to adapt to climate change, local government will have an important role, as the level of government closest to communities, advocating for appropriate policy to state and national governments as well as at an international level. In addition to advocacy, local government will have roles to play in both mitigation of climate change and in adaptation to its inevitable effects. Climate change will need to be considered in every management decision made by local government.

Green spaces and biodiversity confer a number of benefits on local communities. Under climate change it will not be possible to prevent all changes and retain all benefits that have historically occurred at specific locations. Management will need to be responsive to the values the community places on the attributes to be protected. It will therefore be necessary to identify, assess and prioritise those attributes at a regional, site and species level.

In order to inform local government actions to better support species and ecosystems on public and private land to adapt to changes in climate, this project will build on this literature review to conduct technical and stakeholder workshops. These will investigate, collate and document regional climate projections and the appropriate management techniques and responses that may be useful in building resilience. Initial recommendations will be tested by conducting a case study relating to a species or ecosystem within the region covered by the EAGA councils. Through this process it is anticipated that gaps in the current knowledge will emerge and issues for future investigation will be identified and recommendations made.

In recent papers reviewed, climate scientists have described a number of feedback effects, which will reinforce climate change if they are triggered. If that occurs, self-sustaining ‘runaway’ climate change will follow and it will no longer be possible to stop this process. Most climate scientists believe we have not yet crossed any of the feedback thresholds but may be close to doing so.

While the scientific understanding of climate change constantly improves, the emissions trajectory which humanity will choose remains undecided. The documented facts that environmental effects consistent with climate change are occurring earlier and faster that previously predicted, that despite Kyoto, emissions are continuing to increase and that world leaders were unable to reach meaningful agreement in Copenhagen make it seem unlikely that we shall avoid the runaway trajectory and escape massive damaging changes.

Reviewed reports show that without global agreement on, and implementation of, urgent and effective action to reduce greenhouse emissions in the near future, massive biodiversity losses will be unavoidable.

In order to inform local government actions

The research indicates that it is still essential for nations to act to mitigate the most extreme effects of climate change. However, the window of opportunity is rapidly closing. As Steffen et al. conclude, “There is ultimately no substitute for rapid and deep cuts in global emissions of greenhouse gases”.

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