

## CLIMATE CHANGE AND ITS IMPACTS ON AUSTRALIA'S CULTURAL HERITAGE

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### INTRODUCTION

Little has been written in Australia about the impacts of climate change on cultural heritage places (but see Pearson & Williams 1996). The models used to produce predictions of the nature of climate change have been refined to over the last decade, and have produced a range of scenarios that can at least provide a basis for discussing possible impacts on cultural places. Some implications of climate change are already being observed, and are most recently summarised in the 2007 reports of the International Panel on Climate Change (IPCC 2007a and 2007b), which will be referenced through this paper. The paper draws on one presented on behalf of Australia ICOMOS at a UNESCO World Heritage Centre conference on climate change and World Heritage held in Paris in 2006.

In Australia a series of regional models have been developed that allow some degree of refinement in looking at possible impacts across the continent. These draw on and expand the IPCC TAR 2001 reports, and are informed by local data collection and modelling (Intergovernmental Panel on Climate Change 2001; Pittock 2003; Allen Consulting Group 2005; Hennessy, Holper & Pittock 1995.). This modelling suggests a series of possible outcomes for Australia that I will interpret in relation to their potential impacts on cultural heritage conservation issues.

It is useful to remember that if Australia experiences climatic and environmental change as a result of natural cycles and anthropogenic emissions, this will not be the first time that the inhabitants of this continent have lived through changing climatic and massive environmental consequences. Australia has been occupied for at least 40,000 years and possibly as long as 60,000 years or more. In this time the continent has experienced major changes in sea level, precipitation, evaporation, watertable levels, the nature of weather patterns, wind speed and direction, and vegetation types (Bowler et al 1976; Davidson 2002). These changes were considerable - now-dry lakes (such as Willandra World Heritage Area) were once full to overflowing; areas of southern rainforest (Tasmanian Wilderness World Heritage Area) were once open alpine grasslands; and places such as Sydney Harbour were once river valleys located many kilometres from the coast. Australia's prehistoric sites preserve an invaluable record of how people have responded to these changes over many thousands of years. For example, the rate of rise of sea level which occurred during the terminal Pleistocene and early Holocene period may be comparable to projected rates for the current climate change in some scenarios (see Chappell and Thom 1977: Figure 2). Both then and now, rates of climate change are such that resultant environmental changes will be visible within people's lifetimes. What *is* new with the current projections, is that the likely effects

will have been known to society before they occur, and the opportunity exists to make adaptive responses.

The likely worldwide threats posed by climate change to cultural heritage places have been summarised by the World Heritage Centre (World Heritage Centre 2007: 53, 65ff—extrapolated by the author for the Australian context):

Threats to historic buildings and sites include:

- Susceptibility to changing soil moisture in poorly damp-coursed structures;
- Associated salt problems and soil instability, heaving and cracking;
- Increased rain/storm events impacting on poor drainage systems;
- Changed freeze/thaw cycles in highland areas;
- Migration of damaging pests with changing environmental conditions;
- Increased flooding events;
- Coastal erosion;
- Increased storm and wind events;
- Desertification;
- Climatic zone movements impacting cultural landscapes and gardens;
- Increased temperatures and aridity;
- Changing economic and social patterns of settlement.

Threats to the chemical and physical stability of archaeological sites is potentially impacted by;

- Modification of precipitation regimes and increased year-to-year variability;
- Increased droughts and floods;
- Changes in water tables and ground water levels;
- Changes in humidity cycles;
- Changes in soil chemistry;
- Changes in soil temperature;
- Changes in wetting and drying cycles, and salt crystallisation and dissolution;
- Sea-level rise and increased coastal erosion events.

The following sections look in more detail at some of the projected impacts on cultural heritage places, making a somewhat arbitrary division between the coastal zone, the well-watered hinterland areas and the arid interior.

## **IMPACTS IN COASTAL AREAS**

The most obvious risk factors for cultural heritage places are in coastal areas due to sea-level rise. However, the impacts might be more complex than is at first apparent. The IPCC 2007 reports projections suggest a global sea level rise by the decade 2090-2099 of 0.26 to 0.59 m (excluding any future rapid dynamical changes in polar ice cap flows) (IPCC 2007a: 13). Sea level rise, combined with a projected increase in the frequency and severity of tropical cyclones and storm surges, and other extreme weather events in southern Australia, and with increased rainfall in northern Australia will have far more wide-reaching impacts than any one of these factors alone.

A dramatic example is Kakadu National Park, a World Heritage Listed site. Kakadu has an extensive wetlands zone, which makes up 195,000 hectares of park. The low-

lying coastal plain containing the wetlands is just 0.2 to 1.2m above mean high water level, vulnerable to a projected 10-30cm sea level rise by 2030. (Reynolds 2002: 16). The wetlands would potentially suffer from saltwater encroachment, with potentially dramatic impacts on plants, fish, reptiles and migratory birds. (Kakadu National Park 2006: 48, 51; Allen Consulting Group. 2005: 96).

The wetlands zone is important to Aboriginal people for hunting and gathering throughout the year. This has an archaeological and a contemporary cultural significance. Flooding, by direct sea level rise, storm surge or the back-up of flooding rivers, together with saltwater encroachment, could submerge or erode cultural sites in estuarine and coastal zones, or bury them in silt. More importantly, there may be the risk that substantial and prolonged saltwater encroachment and infrastructure damage from increased cyclone and storm surges might disrupt and displace Aboriginal occupation in the wetlands, and cause major relocation of settlements and activities. This might erode or extinguish cultural caretaking of significant sites, and thus diminish an essential element of the World Heritage values of the area.

Mitigation by saltwater barriers in the major waterways and wetlands is being considered, to limit environmental and agricultural impacts (Allen Consulting Group. 2005: 97). A series of Kakadu Landscape Change Projects have been running to study observed change in the Kakadu environment over the last 50 years, which will act as a benchmark for monitoring and developing adaptive responses to climate change impacts.

The potential natural environment impacts of climate change on the Great Barrier Reef have already been foreshadowed by two major coral bleaching events in 1998 (when 16% of the world's reefs and 3% of Australian reefs experienced coral bleaching) and again in 2002. Corals have a high sensitivity to changes in water temperature, a 1°-2°C increase might cause significant stress, and a prolonged temperature rise will kill the coral entirely (Allen Consulting Group. 2005:70). Projections suggest globally sea temperatures could rise above the survival limit. The reef is also threatened by increasing flows of high nutrient turbid water from coastal rivers, and increased rainfall and frequency of severe weather events could accelerate that threat.

Major changes to the ecosystems of the reef would impact dramatically on Indigenous traditional hunting and on cultural associations with sites. Sea level rise and increased extreme weather events would be a threat to Indigenous and historic sites, many of which are on coastal lowland areas.

Cultural heritage places in coastal locations will be at potential risk from the same changes as the natural environment (see IPCC 2007b: 11). Direct sea level rise, increased storm events and increased stream run-off in northern Australia poses threats to Aboriginal shell middens and other low-lying sites around the coast. For example, over 200 shell middens have been found on World Heritage listed Fraser Island. These sites are particularly vulnerable to sea level change and storm activity. CSIRO has estimated that 'soft' coastlines could retreat horizontally by 50-100 times the vertical sea level rise, suggesting a possible recession of sandy beaches by 4.5 to 88 metres by 2100 under certain climate change projections (Allen Consulting Group. 2005: 59) and between 13 and 59 metres under the latest IPCC projections (IPCC 2007a: 13). As Fraser Island is a sand island, it would be highly vulnerable to such climate change.

Similar threats exist for historical coastal infrastructure, such as jetties and wharfs, sea walls, sites on reclaimed land, fortifications, shipwrecks and structures close to current high water mark or in low-lying areas. In coastal urban areas the potential exists for saltwater infiltration of aging sewerage and water reticulation systems, with resulting impacts on historic engineering features, both directly and through contamination of ground water and changes to soil chemistry in archaeological deposits. Some waterside heritage icons, such as Bondi Beach and the Sydney Opera House would appear to be at risk from projected sea level rise. The Sydney opera House is to develop a Heritage Risk Management Plan stemming from its endorsed conservation management plan, but it is not known if this will specifically address sea level rise risks.

Australia's 2002 periodic report to the World Heritage Committee identified that global warming has the potential to cause sea level rises at the edges of the Tasmanian Wilderness World Heritage Area could result in coastal erosion and loss of Aboriginal sites. Historic sites in the region would also be at risk of sea level rise.

### **IMPACTS IN THE 'WELL-WATERED' INLAND**

In the Northern Australian hinterland the key climate change impacts are likely to be related to:

- increased cyclone intensity
- increased extreme rainfall events
- increased temperature
- increased rainfall (especially in areas receiving monsoonal rain)

In the Southern and Eastern Australia well-watered inland the key climate change impacts are likely to be related to:

- increased extreme rainfall and storm events
- increased temperature, more heatwaves and fewer frosts
- increased frequency and intensity of drought
- decreased rainfall

In Northern Australia an example of potential impacts is in the Wet Tropics World Heritage Area, where impacts on the natural environment is likely to have a consequential impact on cultural heritage sites, both physically and in terms of landscape setting and possibly changed landuse pressures. The Wet Tropics WH Area would be impacted by higher air temperatures, resulting in a shift in ecological zones. Wet Tropics rainforest will decrease by 50% of upland rainforest area with only 1°C of global warming (Reynolds 2002). The 2007 IPCC projection is a likely 0.6 to 4.0°C increase by 2099 (IPCC 2007A: 13). The Wet Tropics WH Area could lose as much as 66% of all endemic vertebrates in 50-100 years depending on the rate and timing of climatic variations. (Allen Consulting Group. 2005: 59). No study of the projected impacts on cultural heritage places within the Wet Tropics has been seen by the author.

Increased frequency and intensity of high winds and rainfall events are predicted for both Northern and Southern Australia (Hennessy, Holper, & Pittock 1995). However, modelling has suggested that in SE Australia hail damage is not likely to significantly increase under enhanced greenhouse conditions (Niall & Walsh 2005). Storm damage is a risk posed for heritage structures, especially roof damage and an increased risk to

timber and iron vernacular rural buildings not strengthened to resist high winds. The risk of tree-fall damage and localised flash flooding is also increased.

In South Eastern Australia Cultural heritage places are likely to be at risk both from environmental changes and from associated shifts in landuse and settlement patterns. The well-treed Great Dividing Range and coastal ranges, and the major National Parks and State Forests associated with them, face a major threat from the impact of temperature change on a range of plant species. In the Blue Mountains, of the 82 Eucalypt species central to the World Heritage listing, 30% have a temperature range of less than 6°C and may have difficulty adapting to temperatures predicted for 2070 in NSW. (Hughes, Westoby & Cawsey 1996). In addition, the incidence of bushfires is likely to be increased by changes in temperature, humidity and precipitation, and the rate of drought events (Council of Australian Governments 2004; Allen Consulting Group. 2005: 72-73; World Heritage Centre 2007: 46-47; IPCC 2007b: 11). The loss of 19 huts out of the 83 surviving huts and hut ruins in the Kosciuszko National Park and the loss of further cultural heritage places in the Victorian Alps, the ACT and other areas of NSW in the 2003 bushfires emphasises the risk that increased bushfire frequency and intensity can have on the cultural heritage resource in this zone.

There are likely to be substantial shifts in landuse and settlement patterns in Southern and Eastern Australia as a result of climate change. Production from agriculture is projected to decline over much of the region by 2030 due to increased drought and generally declining rainfall (IPCC 2007b: 11), and the pattern and nature of agricultural production is also likely to change to reflect changing rainfall patterns. This may result in the abandonment of rural properties containing heritage structures, the redundancy in use of some structures, the substantial alteration of rural landscapes, and the depopulation and economic decline of rural towns containing many heritage buildings. As an adaptive response, CSIRO is currently working on a study of the genome of wheat to identify and breed drought tolerant strains. In press coverage it was suggested that if successful, the research might even result in an expansion of the wheat growing area in NSW and Queensland ([www.pi.csiro.au/enewsletter/PDF/PI\\_info\\_DroughtTolerantWheat.pdf](http://www.pi.csiro.au/enewsletter/PDF/PI_info_DroughtTolerantWheat.pdf)). This adaptation to climate change could in itself pose a threat to cultural heritage places, replacing formerly pastoral properties with intensive wheat production, potentially resulting in the removal of heritage buildings related to pastoral production and residence.

As a result of reduced precipitation and increased evaporation, water security problems are projected to intensify by 2030 in southern and eastern Australia (IPCC 2007b: 11). The current drought-related water restrictions highlights the risks posed by water shortages to gardens and elements of cultural landscapes such as street trees, and these risks are likely to increase over time.

Australia's 2002 periodic report to the World Heritage Committee identified that global warming has the potential to cause impacts on alpine and other ecological communities in the Tasmanian Wilderness World Heritage Area. In one sense environmental change due to climate change will have little contextual impact on the Aboriginal sites in the region, as when these were occupied the environment was very different to that which has subsequently evolved. However, the physical impacts accompanying, say, shifts in vegetation zoning due to climate change may have an affect on the sites. Aboriginal

and historic sites at sea level will be vulnerable to the potentially increased run-off and changes in soil chemistry (eg see Chapman 2002).

## **IMPACTS IN THE ARID INTERIOR**

The climate change impacts predicted for rangelands in the interior of Australia include:

- drying climate
- increased dryland salination
- shallow, saline water tables
- increased wind erosion and soil structure decline

Climate change in the interior is likely to reduce rainfall in the region, and droughts are likely to be more frequent and intense. Increased drought frequency would dry the soil, increase wind speeds and associated erosion, and lead to desertification (Allen Consulting Group. 2005: 84).

Little has been published relating to climate change scenerios for cultural heritage places in arid Australia. Studies to establish indicators for state of the environment reporting have discussed the pressure of pastoral activities on soil degradation in the arid and semi-arid rangelands as a threat to archaeological sites (McBryde in Johnston et al 1998: 74, 77-78), but no systematic studies were available to enable such an indicator to be developed. Climate change will exacerbate the pressures on soil loss already felt from pastoral impacts.

The archaeological deposits at Willandra Lakes World Heritage Area have been exposed by past and ongoing wind erosion, but the potential for accelerated erosion into the future poses a question of uncontrolled exposure, potentially to the base of the archaeological deposits.

Salinity is a major environmental issue in Australia, with 2.5 Mha currently affected and the potential to increase to 17 Mha by 2050. However, there has not yet been any comprehensive assessment of the effects of climate change on the spread or intensity of salinity problems (Pittock 2003: 94; Allen Consulting Group 2005: 67), and no analysis of potential impacts on cultural heritage places.

## **POSSIBLE MANAGEMENT ACTIONS**

Much of Australia's response to the assessment of the potential threat posed by climate change is based on impacts on the natural environment. It perceives that the threats are global in scale and cross national boundaries, making it difficult for individual management authorities to take action to mitigate impacts (see Allen Consulting Group. 2005: x-xii; and the Australian response to the questionnaire for the Paris UNESCO meeting). However, little attention has yet been paid to the potential threats posed to cultural heritage values. Many of these threats are able to be mitigated and adaptation strategies are feasible, because many of the cultural values are limited to individual sites and small landscapes (ie buildings and sites might be conserved whereas whole forests or reefs may not).

Perhaps what is needed in relation to the cultural values of World Heritage and other heritage places is:

1. a detailed analysis of the projected regional impacts of climate change on Australia's cultural heritage, so that the nature and scale of the threats can be identified, and the likely vulnerability of cultural places and landscapes assessed (a fine role for the Australian Government to take a lead in);
2. a consolidated and detailed monitoring of recent and ongoing affects related to climate change and climatic events at cultural sites, perhaps employing a variety of monitoring methodologies;
3. the enhanced exchange of information on observed and potential climate change impacts on cultural sites between jurisdictions and with the private sector;
4. the development and ongoing updating of guidelines for mitigation and adaptation approaches to protect a range of cultural sites from climate change impacts, perhaps backed up with a range of case studies;
5. development of disaster mitigation plans for cultural sites at risk, as a component of conservation management plans for sites;
6. initiation of a major site recording program targeting those places at risk of loss or major damage, and for which mitigation will not be possible;
7. the funding of exemplar projects across a range of cultural heritage place types demonstrating appropriate responses to climate change risks.

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