Potential Impacts of Climate Change on Tasmania’s Terrestrial and Marine Biodiversity and Natural Systems
August 2008
POTENTIAL IMPACTS OF CLIMATE CHANGE ON TASMANIA'S TERRESTRIAL AND MARINE BIODIVERSITY AND NATURAL SYSTEMS

Proceedings of a Workshop, Hobart,

22 May 2008

Resource Management & Conservation
Department of Primary Industries & Water
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Scope of Workshop

Tasmania is vulnerable to the changes in climate projected over the next 100 years. This will impact on all areas of community life, including natural diversity and natural resources. Human-induced climate change may lead to significant losses of biodiversity, with a shift in species distribution, community composition and species extinction. The current global extinction rates are 100-1000 times greater than background levels. Habitat loss, fragmentation and degradation, and the impact of invasive species are key threats to biodiversity, and over the next century climate change may result in further large-scale losses of biodiversity, and climate change is predicted to interact and exacerbate these current threats.

There is considerable work happening at the international and national level assessing the potential impact of climate change on biodiversity. The Fourth Assessment Report to the Intergovernmental Panel on Climate Change (“IPCC Report”) was released in 2007 and includes assessments of ecosystems and biodiversity, including an overview for Australia and New Zealand. It should be noted that this report is conservative in its predictions, with the majority of the work based on climate stations and longterm monitoring sites in the Northern Hemisphere. A number of national workshops have been held considering the impacts of climate change on biodiversity, specifically on biodiversity, freshwater ecosystems, the Protected Area Network, bushfires, World Heritage properties and coastal systems.

Tasmanian biodiversity and natural resources are likely to be affected by climate change. Some of the direct effects include reduced soil moisture, reduced streamflow, altered phenology (life cycles) and population dynamics, changed physiological processes and behaviour, and changed distribution (upwards in elevation or towards the poles in response to shifting climate zones). This will in turn impact on changed habitat quality and community structure, with increased plant and animal diseases, and altered fire regimes.

A workshop on 22nd May 2008 in Hobart sought to explore key vulnerabilities to climate change for Tasmania’s natural diversity and natural systems. The aim of this workshop was to identify biodiversity assets and other elements of natural diversity at risk from the impacts of climate change. The workshop explored key vulnerabilities to climate change for Tasmania’s natural diversity and natural systems, including observations from existing research, predictions about key vulnerabilities, interactions between climate change and other threats, and briefly addressed climate change adaptive planning. These proceedings entitled Potential Impacts of Climate Change on Tasmania’s Terrestrial and Marine Biodiversity and Natural Systems in Tasmania are the output of the workshop. Participants were invited to submit a written summary of their three minute presentation (Sections 2, 3 & 4). The agenda (Appendix 1), the keynote speakers’ PowerPoint presentations (Appendix 2) and the list of participants (Appendix 3) are all included in these proceedings.

This is the first of a series of workshops that are part of DPIW’s Building Resilience into Natural Systems: Adaptation to Climate Change Project to addresses the need for the Tasmanian Government and the community to develop and implement adaptation responses to reduce the vulnerability of Tasmania’s natural values to climate change. The information will be used as part of a vulnerability report for broader consultation.
INTRODUCTION: CLIMATE CHANGE IN TASMANIA AND ITS POTENTIAL IMPACT ON NATURAL DIVERSITY AND NATURAL SYSTEMS

Louise Gilfedder
Conservation Policy & Planning, DPIW

Climate change is now unequivocal. Tasmania is vulnerable to the changes in climate projected over the next 100 years. This will impact on all areas of community life, including natural diversity and natural resources. Human-induced climate change may lead to significant losses of biodiversity at a global scale, with a shift in species distribution, community composition and species extinction. The current global extinction rates are 100-1000 times greater than background levels. Habitat loss, fragmentation and degradation, and the impact of invasive species are key threats to biodiversity, and over the next century climate change may result in further large-scale losses of biodiversity, and climate change is predicted to interact and exacerbate these current threats.

There is considerable work happening at the international and national level assessing the potential impact of climate change on biodiversity. The Fourth Assessment Report to the Inter-governmental Panel on Climate Change (“IPCC Report”) was released in 2007 and includes assessments of ecosystems and biodiversity, including an overview for Australia and New Zealand. This report is refereed by thousands of scientists, and is reviewed and approved by almost all of the world’s governments for release. It should be noted that this report is conservative in its predictions, with the majority of the work based on climate stations and long-term monitoring sites in the Northern Hemisphere. A number of national workshops have been held by the Australian Greenhouse Office considering the impacts of climate change on biodiversity, specifically on freshwater ecosystems, pests and diseases, on the National Reserve System, and on improving our predication skills.

The aim of this workshop is to identify biodiversity assets and other elements of natural diversity at risk from the impacts of climate change. The workshop will explore key vulnerabilities to climate change for Tasmania’s natural diversity and natural systems, including observations from existing research, predictions about key vulnerabilities, interactions between climate change and other threats, monitoring and assessment of the impacts of climate change, and current and future climate change adaptive planning. The output will be a summary report on the Potential Impacts of Climate Change on Tasmania’s Natural Diversity, and will include the Powerpoint presentations on keynote speakers as requested at the workshop.

Little coordinated work has happened so far in Tasmania with regard to climate change and biodiversity, and this workshop attempts to address this issue. This is the first opportunity for us to get together as a group to discuss climate change issues, the impacts on our core business and possible responses.

What has happened so far in Tasmania in response?

1. The Adaptation to Climate Change for Tasmania’s Natural Systems Project addresses the need for the Tasmanian Government and the community to develop and implement adaptation responses to reduce the vulnerability of Tasmania’s natural systems and biodiversity to climate change.
The scope of the project is to identify the key vulnerabilities of Tasmania’s natural systems to climate change and to identify the adaptations that may enhance and recover the natural resilience of Tasmania’s ecosystems, plants and animals to the potential impacts of climate change.

2. Informal get-togethers in the Resource Management & Conservation and Strategic Policy & Planning Divisions to identify who is doing what within DPIW and in other agencies.

3. Proposed establishment of a climate change & natural systems working group within RMC. Already it has identified the need to work across government on these issues, including Parks & Wildlife Service, other divisions of DPIW, and colleagues within the Department of Justice.

A second, larger workshop is proposed for October (8-10 October) and will focus on adaptation strategies and management responses and building resilience into ecosystems, and will assess the effectiveness of current approaches.

Climate change prompts questions about what we are conserving.
- Are we managing novel ecosystems, managing processes and structure rather than specific species?
- What is the appropriate scale of response: local or regional?
- How do we manage for resilient systems?
- What is the potential for transformability of ecosystems and how is this influenced by the adaptive capacity of species?

The co-organisers Louise Gilfedder, Jennie Whinam and Oberon Carter thank all participants for their contributions, and John Harkin, Manager of DPIW’s Private Land Conservation Program, for facilitating the workshop.

Special thanks are given to the guest speakers - Ian Barnes-Keoghan, Meteorologist in the Climate Services Section of the Bureau of Meteorology, and Michael Dunlop, Research Scientist with the CSIRO Sustainable Ecosystems.

This workshop was convened to coincide with Michael Dunlop’s visit to Hobart following on from the release of the report on the Implications of Climate Change for Australia’s National Reserve System: A Preliminary Assessment, which he co-authored with Peter Brown. This provided an opportunity to stimulate thinking and discussion on climate change issues within the Resource Management and Conservation Division (RMC) of DPIW. The Workshop involved a snapshot of key issues and current thinking. Speakers were given five minutes to outline what is currently known or predicted within their area of expertise, and provided brief written papers for the Workshop Proceedings.

A second RMC Division Workshop to be held in October 2008 will explore possible management responses and encourage re-thinking of our current business in the context of climate change issues. Following on from these Workshops and a range of broader input, a Draft report will be prepared on Tasmania’s natural values’ vulnerability to climate change, for release for targeted consultation in 2009.
2. Setting the Scene – Climate Change in Tasmania

Climate Change Background
Ian Barnes-Keoghan
Meteorologist, Climate Services Section, Bureau of Meteorology.

(See also Powerpoint slides in Appendix 2)

The following notes were not provided by the speaker, and although they have been vetted they may contain some errors or misrepresentations.

Temperature Trends to 2007
- Global trend data shows a rising mean temperature with relatively small variability. 1998 was the warmest year on record for the globe.
  - Australia: upward trend also but more overall variability based on individual events.
- Tasmania: similar to Australian trend in terms of variability and trend of rising temperature not as strong (variability greater than trend): Tasmania 0.4-0.7 degree change over 100 years and variability similar in magnitude to change.
- Trend in temperature 1970-2007 – Australia: mostly rising temperatures: inland rising more strongly, some patches where temperature is falling or where there are very strong rises. Based on a limited number of data points and extrapolation, the trends may not be supported where fine detail is shown on the map, however the overall trend of rising temperatures is clear.
- Trend in temperature 1970-2007 - Tasmania: autumn slight temperature decrease but overall increasing temperatures across the year. These trends are again based on very few data points.

Rainfall Trends to 2007
- Rainfall has better data. The issue in Australia and Tasmania (including reserves) is that there are large areas where no-one lives, so few observations are available.
- Trend in rainfall 1970-2007 - Australia: Eastern Australia has shown a decrease in rainfall, however there is very little overall trend because the increase in high rainfall in northern areas is balancing the decreases across the rest of the country.
- Rainfall in 1970-2007 - Tasmania: strong decreases in most parts of the State. Decreases throughout in Autumn, general decreases in winter, slight increase in rainfall in spring in the west: so not just decreases but a shift in the timing of rainfall out of autumn into winter-spring particularly on the west coast.
- Macquarie Island 1948-2007: mean temperature increases (around 0.4 degrees) but no obvious trend and large variability, but strong rise in rainfall since 1960s, again high variability. Issue again is that observed period is very short. Annual rainfall rises but ecology of island suggests a drying effect so some inconsistency. Maybe rainfall patterns (time of year, event intensity etc) may be a factor here? (no data).

Climate Science
- Be wary of data and the trends shown. A homogenous series of data is required, with the same instruments and locations. The data for Macquarie Island showed a very strong trend of increased wind strength since the 1960’s. Both rainfall and wind dropped strongly up to 1960’s so this may be part of the reason. But when
the data is examined, it is found to be based on 5 different sites and methods, so the series is heterogeneous and the data is unreliable. This demonstrates the need to be careful in the design and use of observations and ensure homogeneous series are used.

- To properly model, we need an understanding of the current state of each element (eg volcanic activity) and the interactions between each one (eg atmosphere-biosphere interactions). This makes it very complex to model.

- Greenhouse effect overview – see PowerPoint slide

- Anthropogenically enhanced greenhouse effect – see PowerPoint slide. Total amount bouncing around within our atmosphere is comparable to the amount of incoming solar radiation. Changes to any part of the system change not the total amount coming in and out of the atmosphere but the balance within our atmosphere (eg ice reflection; type & location of clouds; vegetation cover absorption; etc). In any individual location the actual is different to the global total shown here.

- Radiative forcing: describe trends in radiation 1750-2005: based on land use change, etc. Mostly result of changes in human activities, with large error bars.

- Climate models are mostly grid-based and similar in structure to weather prediction models. The models cut the atmosphere and ocean into small grids vertically and horizontally and for some parts such as the atmosphere there is a set of equations that will tell you if X at a point in time will be Y at next point in time. Models are improving. For example, they now include specific effects of clouds, ice, ocean, land surface, etc. The Second assessment report included oceans. The Third assessment report included rivers carbon cycle. The Fourth assessment report included chemistry of biota, and more complex interactions with ocean, surface etc. In 1990’s 500km grids were used (Tasmania one grid), now typically 100km (1 degree).

- Most national level climate predictions are too coarse for application in Tasmania, and don’t take into account Tasmania’s considerable topographic variability compared to mainland Australia. Tasmanian climate scenarios have been developed at c. 14 km grid scale, and provides scientifically-based guidance as to what climatic changes may plausibly take place in Tasmania in the next 35 years (McIntosh et al. 2005). More information is given below about predicted trends in temperature and rainfall, provided by this work.

- This is currently being refined by the Climate Futures for Tasmania project, producing climate scenarios at a fine scale (10-15 km) for credible scenarios using over 100 climate variables (ref). This will provide predictions out to 2100. It is a 3 year project expecting results in the next 12 months. Each run of the model takes around 3 months. The project is managed by the Antarctic Climate and Ecosystems (ACE) CRC. The project will request significant input from other organisations.

**Predicted trends in temperature**

- Projected temperature change by 2030 for Australia: For Australia: there are three emissions scenarios (low, med, high). Temperature predictions at 50\textsuperscript{th} percentile (little difference between low, med, high emissions) all trend around 1 degree.
Predicted trends in rainfall

- Tasmania: the model’s resolution is too coarse to be confident of the variability within Tasmania that the model predicts (e.g., less change over southwest and more over northeast). But when it gets to 2070 the trend in variability is a lot more confident (SW<NE). It hints at increasing rainfall in SW but again this is uncertain.

- Websites:
  - Bureau of Meteorology (BOM) [www.bom.gov.au](http://www.bom.gov.au)
  - Intergovernmental Panel on Climate Change (IPCC) [www.ipcc.ch](http://www.ipcc.ch)
  - Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) [www.acecrc.org.au](http://www.acecrc.org.au)

- Questions:
  - Predictions are tracking at top end of emissions rates currently
  - Lightning strikes – no explicit trend, but models suggest there will be changes (e.g., in frequency and significance of events rather than overall trends) as the model is very complex

- Climate Futures for Tasmania project: Observational records for 15km resolution in Tasmania – information available in some areas and in other areas will describe expected climate with error bars around variability. Models cover physical processes that we can capture well. One possible outcome of project will be better modelling of past climate (required to model future climate).
A qualitative approach is needed for the NRS Biodiversity analysis, as quantitative modelling for biodiversity is limited and does not cover the range of variables we are interested in.

Cascade of impacts - changes to environment will affect the biology of individual organisms (growth, breeding, timing etc); this in turn changes how they interact with the environment and one another (affect demography, growth, establishment, competition, predation etc); this leads to changes to abundance and distribution of populations; and changes to many species combine to affect the composition, structure and function of ecosystems; these impact on society (existence of species, ecosystem services eg pollination, carbon storage, water etc).

There is largely increasing uncertainty of effects as we move down cascade of effects. There is good knowledge of the general types of impacts but relatively little good observations of these changes. Most information is on changes in timing of life-cycle events (often spring events like bud-burst, arrival of migrants, emergence of insects) and in distribution (with many more observations of expansion than decline). Note we need to consider other affects that are more difficult to measure as we will still need to respond to them (eg changes in abundance, species interactions and ecosystem processes).

Evolution and adaptation responses are also unclear but will feedback into the Cascade of impacts diagram, and into the global climate system as well as locally.

Other existing pressures on biodiversity also affect the environment and species ecology; these other pressures will often interact with climate impacts.

Types of responses/adaptation

a) ecosystem management effort - probably affects ecology of some individuals and species, and maybe distributions of populations, but does not affect higher order parts of cascade of impacts.

b) can change the global climate environment, and thus slow (or increase!) the rate of the impacts.

c) Can change our expectations of what we want from the biological environment (eg of specific environmental services)

We can expect many changes through the direct impact of climate, but also through indirect impacts due to species–species interactions and combined effects of climate impacts and other existing pressures.

Clear messages from observations and modelling - species will respond in different ways (species-specific) – through changes in distributions, relative abundance, interactions between species, ecosystem processes, threats to species

Change will be a directional and continual - there have been lots of changes in the past and biodiversity has coped with these changes on a short time scale (eg droughts and decadal climate cycles), but current change this will be continual and
directional (in the same way that emerging from a glacial period is, but the changes and impacts will be different).

- It is difficult to predict details of the change. Our approach to responding must accommodate this lack of ability to predict the details (i.e. modelling to predict which changes will occur, then responding to that is likely to be an unsuccessful strategy, though modelling can be used to understand what types of changes might occur, eg IPCC scenarios).

**Three mental models** of the way in which things may change:

a) Most changes are local. Changes in relative abundance of species in situ; eg local expansion of low density species, local declines and some extinctions, structure and function changes; little impact on composition.

b) Rare regional changes dominate local impacts. A few rapid or long-distance range expansions: chances are may not establish or may not have major impacts if they do establish; but there could be a small number with significant flow-on effects on other species and the ecosystems, especially if it is a new functional type or alters ecosystem processes (fire, hydrology, herbivory, nutrient cycling) (based on knowledge of invasive species)

c) Gradual distribution changes (most commonly modelled/talked about) – over time. Gradual shifting in the distribution of most species, typically up-hill or southward. A significant change in composition and gradual change in structure and function.

There is evidence for all of thee types of changes in paleo-records, recent observations and knowledge of responses to other environmental changes and pressures. All of these changes may occur, but which will dominate in any one situation? When monitoring we will need to design systems to look for all three types of change to pick up the trends.

**How will change happen?**

a) **Declines** – will the process be the climate change itself, or interactions with other species, or poor establishment, remnant populations

b) **Expansions** – long-distance dispersal, outliers expanding, will the limitation be dispersal or managing to establish once there?

c) **Drivers** – eg direct impact on species, interactions with species, ecosystem level impacts – any of these could be the cause for a particular species, or a combination

d) **Timing** – gradual, major changes following disturbance events, thresholds (eg 2 degree change much discussion in literature but not much evidence, and not all populations will hit that threshold at the same time), in equilibrium or lagging (some vegetation modelling suggests some species are already 1,000 years out of equilibrium with the current environment).

Note that we shouldn’t have fixed ideas (eg change will be gradual) when planning management responses, rather we should target modelling and monitoring to determine what the nature of the change will be. We will need to be flexible in our approach to deal with the whole range of types of change. Plan responses that are effective for each type of change.
CONSERVATION ISSUES

- **Manage the change to minimise the loss.** Current conservation practice is based on a static view of biodiversity to manage ecological communities as they are now. We now need to manage for the change rather than try to halt the change. This will be challenging to design especially in determining when to intervene. For example, it may be acceptable to allow a species to disappear from a locality, but not to allow species extinction. This will be a difficult area for policy, legislation, etc.

- **Two goals for biodiversity conservation:**
  a) long term - facilitate change and natural adaptation (main objective)
  b) short term - preserve vulnerable and valued elements (safety net)

Examples include:

  - **habitat restoration** – do you use local provenance or try to use species that are “future adapted” or survive better in dry times?
  - **reserve establishment** - Should this be based on current values or what’s likely to be important in the future?
  - **connectivity** – do we connect areas up to facilitate movement and change or do we reduce connectivity because species may impact on the area they move to?
  - **managing environmental flows,**
  - **grazing regimes,**
  - **fire regimes** – do we try to maintain historic frequencies or let them increase if it occurs?

- **Connectivity:** distribution and abundance of species is affected by others; who will be advantaged by connectivity – will it be those that would otherwise suffer, or would it be those that have better adapted moving in and out-competing vulnerable species, for example in alpine areas. .

- **Threats to biodiversity will change.** For example, fragmentation is already an issue. If species will need to move across the landscape then fragmentation is a serious issue. There will be an interaction between the existing threat and climate. Climate change likely to alter the perception of what is a key threat at any one location. We can anticipate threats, but must also monitor and react.

Four particular threats that have a societal context to consider, making them extra hard to manage:

a) **fire regimes** – eg people may not accept increased fire frequency

b) **new species** – Australian species moving into new areas eg cockatoos destroying crops and aggressive species people may not accept, eg wallabies grazing alpine areas. Do people accept it or try to manage and remove them – policy and science gap

c) **water resources** – society wants more water and environment already under stress

d) **land use change** – eg permanent pasture/native component grazing to cropping
(already agricultural land so won’t be captured by legislation generally)

**Single species versus strategic management**

- There will be community pressure for more investment in threatened species, while at the same time there is a need for strategic high level landscape responses such as increasing the reserve system for background resilience in the landscape. Tension between these two philosophies will increase and compete for funding. Challenges include that we won’t have accurate predictions for all species changes – don’t design a planning response that requires this.

- Value chain of information to achieve conservation goals:
  - Current approach: Conserve lots of species – conserve lots of ecosystems – environmental diversity (now) – environmental diversity (future). Ecological community planning – species data and knowledge. Need to tease apart and re-think these approaches. OK to use communities as planning tool in part of the process but don’t express the desired outcome in terms of (specific identified) communities.

- Resilience at three scales - “**what does resilience actually mean under climate change?**” (see PowerPoint):
  a) Individual species: can it survive, changing environment and threats, somewhere to go, intensive preservation
  b) Landscapes: are ecosystems healthy, is species turnover and ecosystem change ok?
  c) Social-ecological systems: is the balance between production and conservation maintained – is one greatly favoured over the other by climate change, will management institutions maintain the balance?

**Development of the National Reserve System**

- Bioregional framework (IBRA and CAR¹) – aim to conserve “a diversity of ecosystem types to provide opportunity for as many species as possible”. C and R capture diversity at 3 scales and are very well designed for dealing with climate change; fundamentals of the framework are really good (BUT … need to fill reserve gaps)

- A to maintain viability. The Adequacy measure needs to encompass more populations; larger areas; more connectivity to accommodate morphing communities. This is very challenging in climate change environment. Nothing is adequate for species that will go extinct, what is viable in the future, etc

- Big challenges for reserve management – when do you facilitate vs preserve, etc?

- Managers will experience the consequences of ecosystem change first but may not have tools and experience to respond.

- Policy and regulatory gaps, and information requirements around change not just what is there now. Also need to understand societal wants/needs, eg wallabies or herbfields?

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¹ Comprehensive, Adequate and Representative
Regional impact assessment
- Looked at seasonal growth pattern variability across Australia and found areas that may be likely to experience particular change as a result of climate change: switch from summer to all year round or winter dominated growing season (Tasmania and southeast Australia). Could lead to significant changes to fire and ecosystem processes and to invasive species from other areas. In most of the rest of Australia the changes will reinforce existing seasonal growth patterns.

Summary:
- Challenge for conservation thinking
- Changing threats - anticipate, monitor and react
- Single species and strategic management
- Coordination and broadscale planning (bioregional) more important
- Bioregional framework for NRS excellent framework, needs to be implemented, adequacy an issue
- Management of reserves
- New information needs - managing uncertainty and climate impacts

Four priorities:
- Important to have a good broad knowledge of different impacts and implications for effective strategic response
- Protect habitat - more of it and more diverse habitat – a strategy that is very robust, it will be effective even if different types of changes dominate
- Manage habitat and reduce threats
- address landscape issues around connectivity, refuges, hydrology and fire

OVERVIEW OF CLIMATE CHANGE GROUPS/ACTIVITIES – NATIONAL AND STATE CONTEXT

Alasdair Wells
Policy Analyst
Strategic Policy Division, DPIW

NATIONAL INITIATIVES

COAG
- Developing a significant climate change agenda, including emissions reduction, renewable energy, and adaptation
- Climate Change and Water Working Group: Water Sub-Group, and Adaptation Sub Group developing Action Plans for various sectors and themes (including coastal, land and marine management)
- Adopted Climate Change Adaptation Framework in 2007

Ministerial Councils
- Significant action through PI and NRM Ministerial Councils (especially through Climate Change in Agriculture and Natural Resource Management (CLAN))
- Climate Change and Action Plans including…
  - Agriculture (2006)
  - Biodiversity (2004)

National Adaptation Agenda
- National Climate Change Adaptation Centre (Canberra)
- National Climate Change Adaptation Research Facility (Griffith Uni, QLD)
- National Climate Change Adaptation Research Networks
- National Climate Change Adaptation Research Plans, including priority themes…
  - Terrestrial biodiversity (shift to natural diversity, & incl cultural diversity?)
  - Marine biodiversity and resources
  - Water and freshwater biodiversity
  - Also: Settlements and infrastructure; Human health; Primary industries; Disaster management and emergency services; Social, economic and institutional dimensions

Garnaut Report
(Draft Feb 08, final due Sept 08) - Highlighting emission rates higher than projected and need to focus on upper not middle and lower ranges. eg sea level rise at top of upper IPCC range.

Bureau of Meteorology – Water and the Land
An integrated suite of information for people involved in primary production, natural resource management, industry, trade and commerce.
CSIRO – Climate Adaptation Flagship

OzClim
- Online version of BioClim (CSIRO). Bioclim has been used for modelling and these types of tools are becoming better and more accessible to use online, etc

Web site: www.ClimateChangeInAustralia.gov.au

STATE

Tasmanian Climate Change Office, DPAC
- Climate Change Strategy
- Dr Kate Crowley’s Framework for Reducing the Tasmanian Government’s Greenhouse Gas Emissions. (DPAC still working on Climate Change Strategy, interim focus is on Kate Crowley’s framework.)
- Climate Champions Workshops (DPIW, held in both Hobart and Launceston)

CSIRO/Hydro study 2006
- 14km grid downscaling, which is significantly higher than National 60km grid and global 120km grid
- highlighted uncertainty in NE Tas. This is also the area where we are observing the most change.

Climate Futures for Tasmania (projections and impacts) (2008-2010)
- consortium led by ACE CRC
- builds on Hydro/CSIRO work
- Projections to 2100, including extreme events
- Sectoral impacts, particularly water and also infrastructure and agriculture
- Includes very high resolution LiDAR imagery for priority settled areas in the State, providing topography and some vegetation structure information

DPIWE Climate Change Project (2003–2006)
- Sharples indicative vulnerability mapping (2006)
  - geomorphology-based
  - erosion and inundation vulnerability

DPIW Climate Change and Coastal Risk Management Project
- extends/improves extreme sea-level probability information
- desk-top audit of vulnerable assets and values
- Template risk management plans
- Case study analysis and testing of risk management plans

Clarence City Council Foreshores Project
- Integrated scientific and socio-economic analysis of risk, and planning/management response options
- this is the most detailed Council work around.
UTAS / TAFI / TIAR
- Landscape Logic: Linking Land and Water Management to Resource Condition
- TasFACE (free air CO₂ enrichment facility – one of only a few research projects looking at the impacts of an enriched carbon atmosphere on species.

- Has limitations, but does show coastal vs inland variations

Website: www.dpiw.tas.gov.au/climatechange (to be revamped soon)
Climate Change and State of the Environment Reporting
Stephen Waight and Liza Fallon
Resource Planning and Development Commission

The legislative requirement for State of the Environment (SoE) Reporting is to report on conditions, trends and changes in the environment, the achievement of resource management objectives and to provide recommendations for action. We use indicators of trends and changes compiled from existing monitoring programs to help fulfil the statutory requirement.

In the 1996 and 2003 SoE reports for Tasmania, a discussion of the implications of climate change for Tasmania was confined largely to the Atmosphere Chapter. Coastal vulnerability and sea-level change were also raised as issues in the Coastal, Estuarine and Marine chapters. In the 1996 SoE Report, the Biodiversity Chapter also noted that 'little is known about the ability of species to adapt to rapid changes in climate'. It was clear that practitioners were concerned even at this stage about this emerging issue.

Climate change is fundamentally affecting our work for the 2008 SoE Report. Climate change is included as a 'condition' issue in the Atmosphere chapter as with previous reports. However, it is also now included as a 'pressure' issue in each of the remaining chapters, including the Natural Values Chapter. The SoE Unit is currently considering options to document some of the biodiversity responses to climate change. Options include the development of an indicator entitled 'Changes in Seasonal Habits of Plants and Animals' or a more general indicator entitled 'Biological Responses to Climate Changes'. Climate change has also been a key factor influencing a major review of the overall chapter framework for the 2008 SoE Report.

It is increasingly clear that climate change cannot be confined to even an expanded suite of indicators. Despite the uncertainty about the relative impact of climate change versus other key pressures or drivers of change, an increasing number of the indicators in the 2008 SoE Report include climate change as part of the explanation of change. For example, any discussion of threatened species and communities has to note that Listing Statements are increasingly referring to climate change as a pressure (e.g. Miena cider gum, Eucalyptus gunnii subsp. divaricata).

Changes in climate significantly alter the nature, mix and impact of many threats facing biodiversity. It may also affect the threats themselves. For example, these factors are relevant when reporting on the changing impacts of pests and diseases in the State.

In this context, climate change researchers provide differing predictions and it essential that the SoE Report documents these uncertainties. For example, some climate-linked researchers predict that increasing levels of carbon dioxide will promote the growth of weeds, whereas other researchers have found some weeds are less vigorous in drier and warmer conditions. Moreover, many native animals in Tasmania could be negatively impacted by changes in climate, particularly if the new conditions favour the survival of animal pests and native animal diseases.

What can be said is that climate change may alter the composition, growth rate, abundance and distribution of native plants and animals, as well as plant weeds and

2 This is a synthesis for SoE provided post-workshop
animal pests and plant and animal diseases. Climate-linked hypotheses predict that new species may establish in the State (such as weeds from agriculture and gardens). Other plant and animal species (both native and exotic) that are currently not considered as invasive pests may also expand and transform the landscape by impacting upon other species and ecosystems in Tasmania. If this eventuated, environmentally stressed native species could become more susceptible to pests and diseases, or less able to compete for resources.

This one example highlights that the impact of climate change is highly uncertain. It also highlights that we are now only starting to understand the complexities of its effects on biodiversity and the environment and what management actions may be appropriate to mitigate climate change impacts in the future.

In Tasmania, there are limited resources to support environmental monitoring. There is a history of one off monitoring of issues, rather than following through with monitoring over the longer term. This seems unlikely to change even in the face of accelerating biodiversity and environmental changes in response to a changing climate. For example, a reconnaissance survey of acid sulphate soils was undertaken in 2003. However, there has been limited subsequent follow up with this monitoring. Given the possible consequences of climate change, there is now a need to monitor for heavy metals released from acid sulphate soils exposed through the drying of lakes and wetlands. From an SoE perspective, perhaps it is timely to open discussion about the priorities for monitoring using indicator or keystone species.
3. Potential Impact on Tasmania's Natural Diversity

**Climate change in Tasmania and its potential impact on natural diversity and natural systems**

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Accelerated climate change has the potential to significantly affect both physical and biological components of Tasmania’s ecosystems. Loss of intrinsically important landforms, or changes in the rate and magnitude of erosional and depositional processes may result in loss or significant modification of natural systems and values, through coastal and fluvial erosion, increased aeolian activity or modification of soil structure (particularly where organosols may be lost through fire or oxidation).

Geomorphology is the key discipline in determining risk of landform modification, and associated effects on biological systems.

**Geomorphology**

Geomorphology comprises currently active landforms and land-forming processes, as well as relict features and their contents resulting from past Earth-surface processes.

Geomorphology has intrinsic importance for nature conservation, and also underpins much landscape science: it is a critical input to Landscape Ecology. It forms a key component of the earth’s Geodiversity (the range of geomorphological, geological and pedological features, systems and processes). Geomorphology is a major input to geoconservation programs (see below) as it addresses the dynamic surface of the Earth most susceptible to anthropogenic change (including accelerated climate change).

In Tasmania, three themes within geomorphology are critical in the assessment of potential effects of climate change, both for their intrinsic value in the management of natural diversity, and to underpin habitat assessment through landscape ecology:

**Coastal geomorphology**

Climate-change induced sea-level rise and associated effects such as storm surge activity have significant consequences for Tasmania, as the state has the longest proportion of coast to land surface area in Australia. The Tasmanian Wilderness WHA contains SE Australia’s longest stretch of natural coastline. Potential effects include loss of significant areas of soft coast, and deposition of eroded and transported sediment in key locations. Both of these processes will have significant impacts on the State’s natural diversity. Sharples (2006) has produced an excellent map of Tasmania’s vulnerability to sea-level rise, including a polygon map of coastal geomorphic units – still partially incomplete – and a completed map of vulnerability to climate change induced effects on coastal geomorphology. This details predicted erosion and sedimentation, along with areas most susceptible to these processes.

**Fluvial Geomorphology**

Climate-change induced effects on rainfall and evapo-transpiration have significant potential to alter the form and processes within Tasmania’s river systems and riparian
zones (Jerie et al. 2003). Increased demand for water consequent on predicted drought scenarios also has important ramifications for stream geomorphology, as dam construction and water extraction (from both surface and groundwater sources) is directly linked with sediment transport, bank and bed erosion and deposition within river channels and linked floodplains. This also has obvious implications for biological habitat.

**Karst geomorphology**

Karst geomorphology refers to landscapes dominated by solutional rather than erosional processes. Karst underpins a significant proportion of Tasmania’s geomorphological systems (Kiernan 1995). Both abiotic and biotic components of karst systems are highly vulnerable to climate change induced alteration of water and sediment flux, including the critical area of surface/groundwater interaction. Subsurface components of karst ecosystems are highly susceptible to even minor changes to surface/groundwater interactions, particularly in water quantity and quality. Acidity of percolation water is critical in determining the health of karst ecosystems, along with changes to suspended and bedload sediment input to cave systems.

**Other geomorphic and pedological systems**

Other systems such as aeolian (dune) systems, periglacial systems, hillslope processes (landslips etc) and peatlands (both lowland and sub-alpine) are also important at the local scale, and may be significantly affected by climate change. Geomorphic, hydrological and pedological process in the buttongrass moorlands of western Tasmania, sphagnum peatlands in the Central Highlands and Macquarie Island are intrinsically important as geomorphological systems, and geo-hydrological processes contribute significantly to ecosystem functions. Climate change is likely to have a significant effect on surface/groundwater interactions which critically affect the health of these systems.

Alterations to coastal sediment supply are likely to affect coastal dune systems through re-activation of stable systems or sediment starvation.

Active periglacial systems may well become ‘extinct’ in Tasmania as they currently occur only on the state’s highest peaks.

Effects on landslip activity are difficult to predict, however many will be linked to changes in the relationship between hillslopes and stream systems, as well as changes in surface/groundwater relationships.

**Geoconservation**

Geoconservation (the conservation of landforms, soils and bedrock features for their intrinsic and ecological values) is concerned with

- maintenance of natural rates and magnitudes of change in key, currently active natural geomorphic, geological and pedological systems
- preservation of significant relict landscape features representing past earth surface processes.

A major current focus within RMC is on the definition of a comprehensive and representative suite of natural reference sites for their intrinsic value and to assess the
condition (or divergence from a pre-European benchmark) of comparable, but degraded landforms. As well as recognising their intrinsic significance for nature conservation, such sites are also useful as templates for rehabilitation. The best representative examples of these critical sites are thematically documented in the Tasmanian Geoconservation database. Sites for river geomorphology are currently being established through the Tasmanian Index of River Condition project. Similar programs will be important for other key themes within geomorphology; critical in documenting the effects of climate change on susceptible geomorphic systems and in planning to increase landscape resilience.

Geoconservation also recognises key landforms, soils and surficial deposits which are now relict, but illustrate the effects of past environments, often Pleistocene in age. Examples include relict glacial, glacio-karst, periglacial, fluvial and coastal landforms which developed under past climates but are now inactive. The contents of these landforms, eg cave sediments and speleothems, pollen and macrofossil-rich swamp deposits, lunette deposits provide critical information relating the effects of past climate change on environmental systems. Appropriate management of these features is critical under climate change scenarios, as they provide evidence of past effects of climate change. Significant research is currently being undertaken by Quaternarists to understand effects of rapid climate change at the close of the last Glacial period (8-10 000 years ago) and the last interglacial (c120 000 years ago). Similarly, these deposits are being used to extend the range of current, restricted climatic records such as rainfall and temperature. Isotopic research into speleothems (cave deposits) has achieved good correlation with measured data, and may potentially be used to extend the record beyond instrumented records in order to more robustly plan for climate change induced rainfall variation (eg Treble et. al 2003).

The majority of these resources are rare, fragile and non-renewable. Careful management of scientific programs utilising relict landforms and their contents will be critical to balance their preservation for intrinsic geoheritage values against their usefulness (when destroyed) for palaeoclimatic research. ESS records the location and significance of these features on the TGD, and is currently developing protocols for their conservation, use and curation.

**LAND REHABILITATION**

Accelerated climate change will require additional input from rehabilitation specialists in all of the geomorphic systems outline above. River and coastal systems will be particularly important, as considerable areas will be prone to accelerated erosion and soil loss, however prioritisation of works will be critical to ensure best value for money. In many cases it will be prudent to ‘draw back’ from river or coastal frontages at risk, rather than attempting to re-instate landforms which will eventually become decoupled from active processes. This is already accepted policy in low-lying coastal areas of Britain and mainland Europe.

**References**


Coastal ecosystems and marine environments are ecosystems that have been identified as vulnerable to the impacts of climate change, including sea level rise, increased storm frequency and intensity, impacting on seabird habitat, coastal wetlands and native vegetation communities. (P.Wells)
**IMPACT OF COASTLINE CHANGE ON COASTAL VEGETATION**  
Tim Rudman  
Senior Vegetation Scientist  
Biodiversity Conservation Branch

**Basis for Assessment**
Coastal vegetation is exposed to a complex of interacting processes triggered by climate change including biological and ecological pressures interacting with introduced weeds, pests and pathogens, habitat fragmentation, land use and coastline change. This assessment is limited to the impact of the physical coastline change.

Coastal vegetation may be divided into roughly 6 different regional floras distributed roughly sequentially from the Furneaux Islands to the south west coast reflecting broad climatic patterns. Within each flora there is a strong zonation of communities orthogonal to and along the coast with changing substrate, landform and salinity. These include strandline beach herbfields, beach grasslands, sedgelands, foredune shrublands, heaths, coastal tussock grasslands, herbfields, scrub, saltmarshes, freshwater wetlands and forest, are also present. Many species are restricted to the littoral plant communities including a number of threatened species eg *Calystegia soldenella*.

Though coastline change is a natural process, it is likely to be accelerated by climate change. Soft sediment coastlines are most at risk from coastal erosion (Sharples 2007) and are the primary focus of this assessment. Though there is a sense that rising sea levels will bring about coastline recession the underlying geomorphic processes that shift sediment on the coast may result in local responses that vary from recession or stability and even progradation. There are short-term cyclic changes in the coastal state (eg the annual changes in beach profile) which will add noise to longer-term trends. Changes in coastal geomorphology can have profound impacts on availability of different habitats on the coast.

**Predicted changes**
There has been an increase in sea-level between 10-20 cm during the last century, with about 14 cm rise on the southeast Tasmanian coast (Sharples 2006). The IPCC (Nicholls *et al.* 2007) prediction a sea-level rise of 18-59 cm by 2099 is based on modelling of six climate scenarios but does not include the contribution from melting ice sheets which are poorly understood. Additional sea level rise from ice melting is possibly 10 to 20 cm but potentially substantially more if the ice sheet melting rates increase (CSIRO 2007). In Tasmania, the predicted southward extension of the warm East Australian Current will result in a sea level rise above that of global background sea level rise.

There is reasonable uncertainty in wind speed predictions though the anticipated synoptic changes indicate the potential for change. Average wind speed is expected to be affected by the southwards contraction of the westerlies that will result in winter and spring wind speeds increasing by 2-5%. However, little change in annual average wind speed is predicted (CSIRO 2007). McIntosh *et al.* (2005) also predicted a strengthening of westerly winds across the state, especially in late winter and early spring. This is likely to increase height of storm surges and frequency of current 100-year storm tide levels with increased windiness (CSIRO 2007).
The physical processes on the coast that climate change is likely to cause are:
- increased flooding of low lying regions
- erosion and landward recession of sandy shores

There is ample indication that the process of climate change is already impacting on coastlines in Tasmania. Truncated Holocene soil profiles are exposed in eroding dunes on beaches at a number of locations around the State. This indicates that local beach recession is at its peak for the last few thousand years. Beach grasslands have disappeared from sections of many beaches eg Ocean Beach and are severely eroded in others. Barways on river mouths are closing as a result of reduced stream flows and coastal lagoons are drying out more frequently or for extended periods. The endangered *Epacris stuartii* population was adversely affected by salt spray as a result of a large storm surge indicating the vulnerability of some highly restricted distribution species on the coast.

The potential changes in coastal vegetation are:
- narrow coastal communities on soft sediments that are bounded by built environment or non native vegetation preventing community migration
- beach grasslands and beach sedgelands will substantially reduce in area affecting rare and restricted distribution species in this habitat eg *Calystegia soldanella*
- dune fields invaded by marram grass, a disturbance specialist capable of outcompeting native grasses coping better with destabilised sands
- coastal rainforest on soft sediments, threatened by fire and erosion
- large tracts of marsupial lawn eg Hannet Inlet may be at risk of inundation, however the community appears mobile and capable of establish many small patches within an eroding beach environment
- freshwater wetlands close to sea level are at risk from salt ground water intrusion and breaching of barrier systems
- a range of frontline beach fordune shrubland communities eg *Leucopogon parviflorus* shrubland will be reduced in extent, though species threats will be limited to rare or restricted distribution species, particularly those with limited dispersal ability or slow population growth eg *Persoonia muelleri* subsp. *densifolia*
- saltmarsh habitat will be pushed inland

As coastline recession progresses coastal tussock grasslands in dune systems are expected to be reduced. This will put threatened species and restricted distribution species found only on coastal dunes at increased risk eg, *Veronica novae hollandiae* and *Stackhousia spathulata*. A few species with good dispersal mechanisms that are currently restricted the more northern floras may migrate southwards eg *Frankenia pauciflora*. Other species such as *Leptospermum laeavigatum* that readily naturalises in the south of the state when planted has not yet been observed to be migrating southward, indicating potential controls on dispersal.

Landscape fragmentation and habitat variability will be a major barrier to many non
wind, bird or sea dispersed species. It shouldn’t be assumed that lateral migration will be common.

**Timeframe**
The changes are happening now and will be progressive but also include some local step changes related to breaching of barrier systems etc.

Actions to monitor, mitigate or adapt to coastline change are required now.

*Increased flooding of low-lying regions, erosion and landward recession of sandy shores are some of the physical processes on the coast that climate change is likely to cause. Saltmarsh communities and marsupial herbfields may disappear where there is not sufficient habitat for landward migration.* (P.Wells)
Threatened species are especially at risk because:
- their numbers are already dangerously low, so an extra threat could push them over the edge
- species with low numbers may have low genetic diversity and therefore be less adaptable to change
- many threatened species are specialists, so especially sensitive to changes

Threatened fauna
Climate affects timing and quantity of resources such as flowering, on which many species depend:

- Climate change may change timing and intensity of flowering of *Eucalyptus globulus* along the east coast of Tasmania, and thus impact the swift parrot. Swift parrots are entirely dependent on the reliable flowering of *Eucalyptus globulus* and *E. ovata*. No alternatives are available. A widespread reduction or changed timing of flowering over a series of years could therefore have a grave effect on breeding success of this species.

- Protect *E. globulus* and *E. ovata* forest communities across the range of swift parrot, to account for difficult-to-predict climate changes. Focus on communities less likely to be affected by the anticipated changes ie: wet *E. globulus* forest.

- Climate change is linked to habitat loss: a particular risk for specialist species with limited distributions and/or mobility.

- Climate change has already been linked to dieback in central and eastern Tasmania. Species with limited distributions that are dependent on one eucalypt species or community, such as the forty-spotted pardalote, will be at particular risk from this process. Pedra Branca skink is an extreme example with no alternative options if its single island habitat becomes no longer suitable.

- Conserve the habitat if possible.

- Create new habitat in areas less likely to be affected (eg for forty-spotted pardalotes, plant white gums on South Bruny Island).

- For mobile species we need predictive modelling to see where the habitat might be moving - conserve these areas and create corridors to them.

- For less mobile species, if habitat exists where species were formerly recorded consider reintroduction/translocation to these areas. (eg forty-spotted pardalote, consider reintroduction to north coast, King Island and Flinders Island).

- If the habitat cannot be conserved or re-created, consider ex situ conservation.
Threatened flora
Factors that may make threatened plants more susceptible to climate change include short-lived seedbank, short-lived species, fire sensitivity, moisture requirement for recruitment, palatability, poor competitiveness, long juvenile phase, disease susceptibility, decline evident in droughts, habitat subject to desiccation, habitat subject to flooding, inbreeding depression, frost tolerance, subject to windthrow, dependence on other species (both plant and animal), intolerance to disturbance, dispersal mode.

Miena cider gum provides an example of dramatic decline in the face of changing climatic conditions interacting with other factors. Miena cider gum grows in poorly drained conditions at the margins of frost hollows and has suffered a rapid decline throughout its narrow range over the last two decades. This is thought to be due to a combination of factors brought to a head by the extended drought. Factors include mortality or severe loss of reproductive capacity of mature trees due to drought stress; canopy seed crops dramatically reduced; succulent regrowth suffers from browsing by brushtail possums; lack of recruitment due to drought and history of grazing and fire, and isolation of mature trees is likely to result in inbreeding depression, reducing viability of progeny. Recovery actions include fencing of mature stands; caging of individual seedlings; and the establishment of seed orchards.

Other climate change management actions for threatened flora we can contemplate putting predicted ‘no hoper’ species into long-term seed storage. Need good predictive modelling techniques for species response to climate change.

Efforts to augment and complement the CAR reserve system to provide threatened species habitat buffers: use biodiversity surrogates including vegetation communities, hybrid swarms, high diversity of dominants, as well as indicator threatened species.
TASMANIAN WILDERNESS WORLD HERITAGE AREA
Michael Driessen
Zoologist (WHA)
Biodiversity Conservation Branch

There will be changes in species numbers, distribution and composition, and the extent that species will be at risk is difficult to predict.

STRENGTHS

• Island State is some protection against introduced pests and disease
• WHA is a large area of reserved land with a diversity of habitats, and thus may have some resilience to climate change.
• The WHA has many ancient species that are clearly survivors
  - strength/weakness?

SIGNIFICANT ECOSYSTEMS (WHA CRITERION 2)

Alpine
• Endemic species restricted to alpine zone eg three species of alpine skink
• Fire sensitive species/communities vulnerable to increased fire risk

Bathurst Channel Marine Community
• Biggest threat is rising water temperature and changing seawater acidity
• Increase in temperatures can reduce climatic envelope for cool water species.
• Increase in temperature could lead to species invasions. One observed change due to rising sea temperature is the hollow-spined sea urchin. Originally native to NSW, it was first detected in Tasmanian in 1978 and has since become abundant along the east coast of Tasmania. One specimen was collected in Bathurst Channel in 2005.
• A major reduction in rainfall would threaten this unique community through reduction in the depth and transparency of the halocline and increased penetration of macroalgae into the sessile invertebrate zone

Buttongrass moorlands
• Climatic limit for peat formation
• Changing fire regimes will affect the successional process between buttongrass moorland and rainforest

Tall Eucalypt Forest
• At risk from increased fire frequency/intensity
**Exceptional Beauty & Superlative Natural Phenomena (WHA Criterion 3)**

- Glow-worms - reduced water flow will reduce the glow-worm display
- Bathurst Channel/Buttongrass Moorland/Tall Eucalypt Forest – risks for these communities mentioned above

**Conservation of Biological Diversity (WHA Criterion 4)**

- High levels of species endemism
- Relicts of Ancient Fauna and Flora
- Threatened species and naturally rare species (not listed)
  - Are these species more or less at risk?
  - Species with restricted distributions, that are primitive or long-lived may be less able to cope with change.

**Threats**

**Disease and Introduced Animals**

- Risk assessments for pests and diseases establishing in Tasmania are based on current climate.
- Many Australian mainland species are blown to Tasmania on hot northerlies. More species may colonise with increasing temperature. Also many exotic species that make it to Tasmania fail to establish under current climate conditions but this could change.
- Import of animals to the State (eg for pets) are based on potential for the animals to survive in the wild in Tasmania.

**Fire**

- Altered fire regimes

**Competition**

- Between immediate human needs (short term relief) and the longer term human needs (environment).

**Monitoring (Flora & Fauna)**

- WARRA-Mt Weld altitudinal transect. Survey in 2000-01. To be repeated in 2010-11.
- Mt Rufus Transect.
Potential Impacts of Climate Change on Tasmania’s Biodiversity

Impacts of Climate Change on Peatlands and Alpine Ecosystems

Jennie Whinam
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Peatlands
- The peatlands of the TWWHA comprise large parts of the most extensive temperate blanket bogs in the southern hemisphere (1 million ha), mostly undisturbed
- Hydrophobic peats occurring in buttongrass moorlands and burnt Sphagnum peatlands – surface ponding of water, but drier subsurface peats, with no/little water even down to the watertable – loss of functionality in the system
- Drying out of Sphagnum moss around the margins of peatlands
- Invasion of Sphagnum peatlands by woody shrubs, resulting in a dense (fire promoting) shrub layer
- Most peatlands in Tasmania are probably not accumulating peat currently – some are likely to be oxidising.
- Sphagnum peats and rainforest organic soils are important stores of carbon, however a 1-2 cm change in the water table can cause them to become carbon sources rather than sinks.
- In some areas pH is moderating (less acid) coinciding with dry conditions, which may result in other species out-competing the currently dominant acid-loving species (e.g. buttongrass, Sphagnum)
- Likely to be subject to more frequent/greater intensity fires – possibility that fires will have greater impact with drier sub-surface peats ⇒ shifts to drier, less acid community types and loss of peat. For example, King Island fires in 2007 burnt more than 150 ha of peat to an average depth of 50 cm.

Alpine
- The Tasmanian alpine ecosystem is distinguished by high vascular plant diversity and endemic richness (70% of the vascular plants on some western mountaintops are endemic)
- Treeline advancing – several age classes of Eucalyptus coccifera now present above the established treeline on Mt Rufus (with establishment higher up on the eastern side cf. with the western side of the ridge)
- Increased woodiness in the alpine zone is likely to lead to greater fire risk
- Endemic, primitive, long-lived conifers – a prized resource for climate change studies (dendrochronology), but at risk from periods of drought and increased fire threat (traditionally, high altitude lightning strikes were followed by rain, but this is no longer the case)
- Dieback evident in many conifers – Microcachrys tetragona, Athrotaxis cupressoides, A. selaginoides, Lagarostrobos franklinii and Pherosphaera hookeriana (Microstrobus niphophilus)
- Its possible that species at the biogeographical margins (such as A. cupressoides...
at Pine Lake) are likely to be more at risk from climate change

- Widespread dieback of montane/high altitude eucalypts from Lake St Clair, across the Central Plateau and beyond Cradle Mountain
- Dieback and decline in *Eucalyptus gunnii* across the highlands of Tasmania
- Snowpatch communities likely to decline with predictions of less snow
- Fjeldmark – a rare community type, with nowhere to retreat to
- Some of the at risk communities above the snowline are also at risk from ski developments – particularly at Ben Lomond
- Possible risk to alpine species from *Phytophthora* as conditions ameliorate

_Freshwater alpine ecosystems have high levels of endemism and are environments predicted to be sensitive to the potential impacts of climate change._ (L.Gilfedder)
**Impacts of Climate Change on Subantarctic Macquarie Island**  
**Jennie Whinam**  
Senior Ecologist  
Biodiversity Conservation Branch, DPIW

**Subantarctic Macquarie Island**

- Sea-level rise is likely to significantly impact on the coastal terrace – with consequences for the giant bull kelp, thousands of breeding penguins (including the endemic royals) and seals (including the listed threatened elephant seals) – all of which are restricted to breeding on the coastal terraces/beaches.

- Rabbit breeding has significantly increased from producing a single successful litter per year to 2-3 litters per year, as the burrows are no longer flooded regularly – currently causing widespread devastation on the slopes and to the flora; has resulted in a shifting prey base, with rabbits plentiful across the island ⇒ changes in the nutrient cycle for plants; spread of (bird) predators away from traditional food sources (rookeries, seal colonies) with impacts on burrowing bird species (aggravated by the loss of vegetation cover).

- Combination of drier conditions and rabbit impacts has resulted in a widespread increase in *Acaena* on Macquarie – and has been observed on the Kerguelen archipelago.

- Greater risk that weed species will establish from the accidental importation of seed propagules – *Rumex crispus* (now an invasive species on Marion Island) and *Anthoxanthum odoratum* have already been removed from known single populations.

- The isthmus – with the entire associated station infrastructure – is likely to be inundated with a reported increase in sea surges during storms.

*Rising sea levels and storm surges threaten Macquarie Island’s wildlife. (D.Lee)*
PERCEIVED EFFECTS OF CLIMATE CHANGE ON TASMANIAN WETLANDS
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Biodiversity Conservation Branch, DPIW

In Tasmania in the past few decades there has been:
- An apparent decrease in the amount of rainfall,
- An apparent change in the seasonality of rainfall (drier winters and wetter summers).
- An increase in temperature and evaporation rate.

This has led to:
- Drying of wetlands previously thought to be “permanent”.
- An inability to refill even with average rainfall because it falls in summer and evaporates before winter.
- Reduced waterbird breeding activity and success because adults fail to breed or water evaporates before young reach the flying stage.
- A reduction in the amount of food plants and invertebrates in wetlands.
- An increase in salinity levels due to lack of freshwater inflow and high evaporation.
- Birds retreat to coastal estuarine systems, which are now more saline, and may not be valuable refuges in the future.
- An exposure of previously covered acid sulphate soils. Study about to begin in Tasmania looking at this. Examples in other states of this issue: acidic and releasing toxic heavy metals eg Lake Alexandrina.
- Potential loss of some threatened species because of loss of suitable habitat (eg green and gold frog and great-crested grebe – Lake Dulverton was the only known breeding site and has been dry since 1990’s)
- Potential for an increase in the number and range of invasive species
- Possibility of increased disease risk
MARINE IMPACTS OF CLIMATE CHANGE IN TASMANIA
Drew Lee
Project Manager (Marine Conservation)
Biodiversity Conservation Branch, DPIW

SYSTEM EFFECTS OF CLIMATE CHANGE

- All climate change scenarios indicate a decrease in marine productivity.
- Already seeing an increase in southward extent of East Australian Current.
- As a result South Eastern Tasmania is expected to show the greatest SST warming in the Southern Hemisphere.
- Leeuwin Current may decrease in strength effecting west coast upwelling
- Changes in ocean chemistry (increase acidity) - decreased calcium deposition of lower food web.
- Climate change will likely impact on lower trophic orders directly, therefore having an indirect effect on higher order predators (Seals, Whales, Seabirds).
- Earlier peak in seasonal distribution, Tas end of the line for many coastal and shelf species. Limited capacity to absorb change for endemic species.

HABITAT

- Kelp forests already reducing in distribution and abundance; large declines over last 50 years attributed to rising sea temperature.
- A decrease in zonal westerly winds will inhibit East Coast Tasmanian upwelling events and a strengthening of the EAC will limit impingement of nutrient rich southern waters.
- Warmer ocean temperatures now support species that were not viable due to winter temperatures (viable larval offspring).
- Centrostephanus rogersii (sea urchin) established in Tasmania, presumably be larval transport by EAC. Outbreaks are known to cause barrens, and are able to produce viable offspring in waters above 12C, self-sustaining population.
- Coastal habitat encroachment due to increased storm events and sea-level rise.

SPECIES OF INTEREST

Seabirds
- Changes in timing of phytoplankton production will have implications for migratory species - whales, seabirds etc.... do they have the plasticity to adapt?
- Alteration of currents effecting foraging.
- Sea level rise likely to impact on coastal nesting species (ie. penguins, storm petrels), increase in formation of steep dune walls (limiting access) and submergence of low-lying islands during storm surges.
- High site fidelity may impact on ability to relocate.
- Shift in phenology of synchronised breeding birds (will impact on long term field planning)
- Species that rely on Tasmania as a staging point to exploit antarctic krill will be impacted by ice depletion and resulting loss of krill abundance. (eg: Shearwaters)

**Seals**
- Change in fish assemblages, increased fisheries pressures.
- Displacement from breeding areas and large increase in pup mortality due to storm surges and sea-level rise.
- Expansion of Australian Fur Seals into southern islands (Maatsuyker Group), implications for rare New Zealand Fur Seal.

**Whales**
- Krill based species likely to shift in response to declines in krill abundance.
- Migratory species of great concern, do they have the plasticity to adapt to changes in phytoplankton production?
- Changes in timing of migrations, social structure (cohorts).
- Low fecundity makes whales highly vulnerable to climate change.

*Changes to food sources could put whales at risk. (D.Lee)*
Freshwater Ecosystems
Bryce Graham
Manager (Water Assessment)
Water Resources Division

- Major impact for freshwater ecosystems are changes in flow regime. Work from CSIRO shows that a 10% reduction in rainfall equates to 20-30% decrease in flows. Stream gauge sites show between 15-30% reduction in stream flow over the last 15 years compared to historic records.

- In summer there are issues with temperature and connectivity throughout rivers where small pools develop that are not connected, and subject to temperature rises.

- Holistic approach to environmental flow assessment and monitoring including timing of events where signals for spawning and migration. Not simply focused on the low flow part of hydrological regime.

- Currently use AusRivers to monitor, but it is probably not detailed enough to provide required results, only pick up very major events and changes. Systematic monitoring focus could be on hydrology as it’s a signal to look at other issues that may be impacted eg lower than average flows may cause connectivity and migration issues for fish species.

- Major issue is how to balance environmental and social values. Issues arise when trying to convince farmers to maintain environmental flows in rivers. National Water Initiative says any change in climate or yield must be borne by users not the environment, but not sure how this will be played out.

- Historically use records of natural flow, but recognise landscape has changed in last 15 years, policy change to use ~25 years of records when making assessment being considered to address this.

- COAG process has the sustainable yield project for Murray Darling Basin extended to Tas and will include some climate change modelling/monitoring. Due for completion in Dec 2009.

- CFEV database will change dramatically with climate change as includes modelled climate.
The Private Land Conservation Program (as a State and Federally funded program) faces the challenge of developing and maintaining a viable network of private reserves within the context of increasing impacts associated with predicted climate change.

By the end of next year there are likely to be around 500 privately owned reserves covering approx. 45,000 hectares. Most of these were selected primarily on the basis of rarity (CAR values).

It will be increasingly important to identify those areas for reservation that are most significant in terms of their contributions to Tasmania’s, Australia’s and the world’s biodiversity so that resources for management of natural values can be allocated appropriately.

Given predicted climate change impacts to natural diversity, DPIW has a responsibility to ensure the appropriate planning of reserves and development of workable conservation mechanisms for protection of natural values across a range of land tenures.

PLCP is considering the need to identify threats to natural values in private land reserves at local (property) and identify opportunities for building a reservation network in a broader landscape context.

Some immediate questions

- What unreserved areas on private land need to be targeted for conservation, in light of predicted climate change impacts?
- For which priority natural values is increased reservation on private land the best management option?
- How can the ecological viability of the existing reserve network (across public and private) be strengthened or improved?
- Do existing management prescriptions for private reserves appropriately deal with future impacts?
- Where should linkages between reserves be placed? With limited predictive understanding of dispersal or movement of species under climate change, placement of new reserves or linkage areas may be akin to ‘hitting multiple moving targets’ (Dunlop and Brown 2008). Multiple mechanisms may be therefore necessary to address this problem.

Adopting or refining basic reserve design principles

- Aim for larger, contiguous areas of native vegetation.
- Link reserves to facilitate movement through space. Integrate core areas with appropriately managed buffer (supporting areas) within the landscape.
- Build reserves or reserve networks that capture ecological gradients, e.g.
rainforest, to wet forest, to dry forest to grassland to wetland etc.

New challenges

• Reconciling large areas of contiguous vegetation (important for maintenance of species, processes etc) with risks of detrimental impacts of fire or weed or disease spread.

• Planning reserves when movement of species (or ecosystems) is difficult to predict.

• Choosing what to sacrifice. There may be a need to broaden focus from ‘species’ towards communities, structural vegetation types or landscapes.

• Prioritising where to invest conservation effort.

• Increasing flexibility in conservation approaches and mechanisms used, to accommodate new land-use contexts. (eg: pasture converted to cropping).

• Strengthening the connection between the public and private reserve systems.

• Improving engagement and relationship building with landholders and stakeholders under stress; the success of this will directly affect the success of conservation efforts. It will be important to get landholders on board in both core conservation areas and surrounding buffer areas to maintain a viable reserve system.

References

POTENTIAL IMPACTS OF CLIMATE CHANGE ON TASMANIA’S BIODIVERSITY
LOUISE GILFEDDER
CONSERVATION POLICY & PLANNING BRANCH, DPIW

Dry sclerophyll forests and woodlands and lowland grasslands are largely confined to the lower rainfall regions of central and eastern Tasmania. These regions are predicted to experience warming and drying in the next few decades, and are also largely agricultural landscapes.

The widespread death of dominant eucalypts in rural areas since the 1970’s (white gum and black peppermint), and more recently death of montane species (yellow gums at Cradle Mountain, gum-top stringy bark at Great Lake etc) have been linked to a 30 year autumn-deficit in rainfall. The extensive loss and possible future extinction of the Miena cider gum (Eucalyptus gunnii ssp. divaricata) on the eastern Central Plateau has followed widespread drought-related death and failed regeneration. Around 25% of eucalypts are considered to have a 1-degree temperature tolerance – it may be the widespread rural tree decline of the past three decades is reflecting such a sensitivity.

Continued drought is also affecting understorey condition and wildlife habitat. There is anecdotal evidence of declining bird populations, and local extinctions in the past two years, with a failed return of migrants in coastal woodland communities.

TasFACE and lowland grassland research
• Mark Hovenden, Amity Williams and colleagues at the Uni of Tasmania are studying the impacts of the predicted climate of 2040 (2°C and CO₂ at 550 ppm) on soil carbon storage, pasture productivity, population dynamics, nutrient availability etc. in native Australian temperate grasslands (Williams et al. 2007).

Results so far (3 years of data)
• Population growth of Themeda triandra, a perennial C4 grass, was largely unaffected by either factor but population growth of Austrodanthonia caespitosa, a perennial C3 grass, was reduced substantially in elevated CO₂ plots, with reduced reproduction, germination and soil moisture, probably due to increased soil evaporation.
• increased growth in Themeda (C4)
• reduced growth rate of weeds with warming (reduced germination, seedling establishment and seed production)
• increased CO₂ led to increased seed production in flatweeds
• soil nitrogen availability at CO₂ at 550 ppm is half that at 370 ppm.(unpublished)

Implications of TasFACE research so far
• C3 plants are generally hypothesised to be stimulated by increased CO₂ but have been limited by the availability of CO₂.
• Results indicate that predictions based on physiology are not necessarily correct. Authors conclude that the way species respond to secondary factors such as soil moisture is a stronger determinant of population dynamics than photosynthetic pathways/physiology.
There is currently some work looking at water flow through soils. Preferential flow patterns through the soil profile become even more specific when soils dry out. This means that wetting / re-wetting of dry soils may be problematic due to hard setting or the development of hydrophobic surfaces. The prediction of more severe rainfall events increases the likelihood of water either running off or passing quickly through the profile, thus having very little effect on soil hydration and plant growth. This problem is exacerbated on hard setting, duplex or sodic soils, which are common in the south of the State.

Other soils at risk from climate change include peat soils. Observations show that these soils are drying out and developing high degrees of hydrophobicity. The risk of fire to drying organosols is very high. A trial is under way in the Gelignite Creek area to monitor the effects of fire on the hydrology of the catchment. It is expected that this trial will be completed by mid 2009. These soils are included in the State-wide Soil Condition, Monitoring and Evaluation project. Base-line physical and chemical data have been gathered and sites will be re-visited every five years. Long term monitoring of these sites will provide trend data on land use and climate change.
4. Interaction of Current Threats with Climate Change

**Potential Phytophthora Cinnamomi Response to Climate Change in Tasmania**
Tim Rudman
Senior Vegetation Scientist
Biodiversity Conservation Branch, DPIW

**Basis for Prediction**
The magnitude of the changes in the distribution and impact of *Phytophthora cinnamomi* that will result from climate change is dependant on a number of interacting factors. The complex host, pathogen and soil microflora interactions may change with changing climate to either exacerbate or reduce disease incidence. For example changed plant physiological responses under higher CO2 concentrations, or changed soil fungal populations may interact in novel ways with *P. cinnamomi*. Where *P. cinnamomi* is able to expand into higher elevations the impact on species currently at those elevations will depend on their geographic response to climate change.

*Phytophthora cinnamomi* is limited in Tasmania to localities where soils warm sufficiently (presently below about 700m) or hold sufficient moisture for at least part of the year (> 600mm p.a.) for growth and reproduction to occur. A closed forest canopy will suppress soil temperatures also preventing disease development in tall scrub, wet forest and rainforest.

**Predicted changes**
Changes in rainfall are likely to decrease the activity of *P. cinnamomi* in the areas of the state where rainfall may fall below about 600mm p.a. Localised disease is still possible in low rainfall zones in moisture gaining sites eg as low as 400 mm p.a. in Western Australia. Changes in temperature may have two effects of *P. cinnamomi* distribution. It may cause disease at higher altitudes than at present or in forest types currently too cool for disease development. The critical climate component for increasing the disease threat is temperature. Rainfall is likely to decrease the disease threat and may mitigate temperature affects.

Using the 2030 predictions the variation in temperature and rainfall are more sensitive to model function than CO2 scenarios. Warming of around 0.5°C is predicted for Tasmania by 2030, with an upper prediction of about 1°C (CSIRO and ABM 2007). Inland areas and the summer when *P. cinnamomi* is most active will experience greater warming. Modelling of temperature trends under an A2 emissions scenario within Tasmania suggested that there would be little temperature change in the west of the State up until 2040, while the east of the state had a greater potential warming. McIntosh et al. (2005) predicted an increase in rainfall of about 10% by 2040 in the SW half of the State and a decrease in rainfall of 10-20% in the NE half with increased seasonality. It is unlikely that major increases in the areas susceptible to *Phytophthora cinnamomi* as a result of temperature increases will happen up to 2040. Increasing severity of droughts as recently experienced may reduce the activity of *P. cinnamomi* in marginal areas in the NE half of the State.

By 2070 there is a large variation in modelled climate outcomes under the various
emission scenarios. Precipitation changes are expected to be larger than in 2040 with increased seasonality. Coarser modelling used for 2070 suggested a probability of up to 30% in NE Tasmania for a 10% decline in rainfall (CSIRO and ABM 2007). A 30% chance of > 2°C warming and less than 10% chance of >4°C warming in Tasmania by 2070 was also predicted. The models do not currently allow for the local variation expected in temperature and rainfall change over time expected in mountainous landscapes and coastal areas. These may be a degree or more in magnitude different from the regional average temperature predictions (CSIRO and ABM 2007). Under the upper scenario for temperature increase by 2070 considerable changes in the potential distribution and impact of *P. cinnamomi* are possible. Significantly the regions of the State affected are expected to change.

Soil type has a major bearing on the severity of disease in plant communities and it would be expected that significant *P. cinnamomi* infestations in new climatically suitable regions would be largely limited to nutrient poor soils as it is presently. However the novel interaction of soil chemistry changes, soil microflora and plant physiology may affect *P. cinnamomi* behaviour as CO2 levels substantially increase.

Upward shifts of the range of *P. cinnamomi* into higher altitudes are likely, particularly in the east of the State where the highest records are currently at about 800m. In the south west disease is currently limited to about 650m. Based on temperature lapse rates alone an increase of 2°C may increase the height of *P. cinnamomi* infestation in the far SW from around 650m to over 800m, the current lower boundary for alpine vegetation in the SW. If the warm boundary on alpine vegetation is slow to respond to change it is possible *P. cinnamomi* may come into contact with alpine communities. This already occurs for some alpine species that occur locally at lower elevations, such as *Sprengelia distichophylla*, which is highly susceptible to *P. cinnamomi*. The potential for disease in alpine communities would remove the altitudinal refuge this species has from *P. cinnamomi*. It is unlikely that core alpine habitat will be exposed to *P. cinnamomi* based on the modelled scenarios used. A greater understanding of soil warming in open alpine vegetation is required to understand the potential for higher elevations to become susceptible to disease.

The interaction of the vegetation canopy in montane forest is likely to suppress disease and act as a barrier for upward spread. Mountains most at risk have existing *P. cinnamomi* infestations on their lower slopes and continuous open vegetation leading into the subalpine eg many southwestern mountains. Subalpine or alpine vegetation cover similarly may mitigate soil warming if sufficiently dense. Little is known of the susceptibility of subalpine or alpine species however families well represented with susceptible species are present in these floras. However, whether these communities will persist to the point where *P. cinnamomi* becomes a significant conservation concern at altitude is uncertain.

Warming forest soils as a result of increasing temperatures is potentially the most significant change in the threat from *P. cinnamomi*. At present only lowland burnt wet forest or rainforest has sufficient sun exposure for soil temperatures to reach the threshold for *P. cinnamomi* reproduction. Should undisturbed wet forest and rainforest soils warm sufficiently beyond 12°C for periods over the summer, and sufficient moisture is present, disease could develop. Rainforest and wet forest in lowland areas are most likely to be at risk. However, whether this is possible without other
fundamental climate driven changes to the rainforests for example is uncertain.

Soil temperature data from under *Eucalyptus nitida* forest in western Tasmania indicate the temperature buffer to *P. cinnamomi* infestation may be small in some locations. Temperatures of 12°C were reached in the top of the mineral soil B horizon and in excess of 12°C in the organic A horizon (Tim Rudman unpublished data). A range of wet forest and scrub species may be affected eg. *Monotoca* spp, *Cyathodes glauca*, *Tasmania lanceolata*, *Cenarrhenes nitida*. Some species such as *Agastachys odorata* currently rely on wet forest refugia from *P. cinnamomi* that may be reduced or lost with climate change.

The keystone species *Nothofagus cunninghamii* is susceptible to *P. cinnamomi*. Should it be highly susceptible, *P. cinnamomi* could have devastating consequences for infected lowland rainforest. Forest types on nutrient poor substrates or soils will be most at risk such as *Nothofagus-Phyllocladus* short rainforest. Similarly *Eucalyptus obliqua*, has been locally susceptible to disease in Victorian forests and in rare instances in Tasmania. Should warming soil expose the large tracts of *E. obliqua* wet forest to *P. cinnamomi* there is potential for an increase in disease events in this species where site factors are suitable.

Roads, particularly gravel roads are a major corridor for spread of *P. cinnamomi*. The wet forest road network is in places already infested by *P. cinnamomi*, however it does not pose a risk to the surrounding vegetation at present. Climate change may impose a change to the management of the extensive road network in wet forests throughout Tasmania to reduce the risk of *P. cinnamomi* spread.

Spread rates for *P. cinnamomi* may be slow in responding to climate change. Uphill spread occurs at a metre or less a year unless aided by people or wildlife. Many natural boundaries to progressive spread are likely to be maintained and the management of human actions will have a large impact on the extent to which the potential expansion of *P. cinnamomi* into new areas will be realised. While in the east of the state in particular reductions in disease activity or range may eventuate due to decreasing rainfall.

**Knowledge Requirements**

- A model of local microclimatic variation in major ecotypes across the state across the state including soil temperature variation.

- Soil temperature models are required for closed forest and alpine communities, identify change thresholds that raise the soil temperature above 12°C.

- A model for wet forest, rainforest, subalpine and alpine vegetation responses to warming climate.

- *Phytophthora cinnamomi* monitoring in representative areas for range extension and behavioural change.

- Species susceptibility testing is required for potentially susceptible keystone species, threatened species etc.

- A model for how plant physiological and soil property changes may affect *P.*
Mitigation Options
Extend *P. cinnamomi* planning and management prescriptions to vegetation types and areas potentially at risk eg. wet forests and rainforests and subalpine areas.

Timeframe
No significant changes in *P. cinnamomi* range expected prior to 2020, time critical post 2040 as range changes become more likely. There may be step changes in habitat suitability in forests and gradual changes in altitudinal habitat availability. *P. cinnamomi* distributional change is likely to be gradual.

Policy Implications
Management regimes do not require new policy. Existing policy requires reassessment of areas of application.

Stakeholders affected
- Parks and Wildlife Service
- Forestry Tasmania
- Landholders - Private Reserves/Private Forest Reserves
- Eco Tourism Industry

References

NATURAL DIVERSITY RISKS FROM FIRE AND CLIMATE CHANGE
Adrian Pyrke
Manager Fire Operations
Department of Environment, Parks, Heritage and the Arts

A recent report (Lucas et al., 2007) suggests that, on the basis of climate simulations, no significant change in bushfire weather is expected for Hobart and Launceston by 2050. There is good reason, however, to suspect that the climate change influence on bushfires may not be benign for the natural environment in Tasmania.

Climatic factors that could have significant ecological impacts have not been modelled yet. For example, an increase in dry lightning events, drier summers in western Tasmania (could occur even with an increase in total annual rainfall) and increased number of severe fire weather days.

There are some apparent changes in the past 20 years in both weather and fire activity that may be indicative of longer term trends. For example, Hobart weather data indicates that the number of days in spring with Forest Fire Danger Index values of >40 has increased 400% in the decade 1997-2006 compared to 1987-1996. It is extreme fire weather days such as these when the majority of the total annual area gets burnt.

In the decade of fire seasons 1991-2000, PWS records show 14 lightning fires were recorded on reserved land with a total area burnt of 11,245 ha. In the seven fire seasons from 2000-2001 onwards there were 55 lightning fires and 160,698 ha of reserve land burnt. Lightning is now the major cause of wildfire in the TWWHA, whereas in 1986 it was considered that: “In Tasmania there is no strong relationship between thunderstorms and fire.” (Bowman and Brown 1986).

Some possible trends in bushfires and natural diversity that may result from climate change are:

- Greater total area burnt by unplanned fires on an annual basis resulting from an increased frequency of severe fire weather days – there is evidence for this from fire simulation modelling.

- Greater area burnt of rainforest, alpine vegetation and organic soils, if there is a continued trend of dry lightning and higher Soil Dryness Index (SDI) values in western Tasmania in the fire season months from November to March.

- Reduced inter-fire intervals in fire-adapted vegetation such as dry forest and heathland, resulting from the increased total area burnt. This would favour some plant species and disadvantage others (e.g. obligate seeding shrubs). It may also lead to changes in habitat structure and therefore fauna utilisation.

- An increase in the frequency of drought events resulting in poor post-fire recruitment of plant species in fire-adapted vegetation, thus there is likely to be an impact even in drier ecosystems.
References


*Peat destruction from wildfire on King Island. Lavinia Nature Reserve has had two wildfires in the past five years, destroying peat that was metres thick and thousands of years old. This area was originally under Melaleuca ericifolia scrub. (R.Schahinger)*
Weeds are plants, too.

The principal impact of climate change is (or should be) to challenge our assumptions regarding weed management.

It is often assumed that weeds are not as important as native flora when conservation surveys are undertaken. Conversely, weeds are sometimes considered to be worse/more resilient than they are.

It is worth bearing in mind that this is a global problem requiring global solutions, and that a small weed infestation capable of being eradicated in Tasmania may also be viewed as an ex-situ insurance population.

The three broad climate change factors:
- change in temperatures, with increase most widespread
- steady rise in CO₂
- fluctuation in amount, intensity and interval of rainfall

All these factors have significant impacts on plants. The amount of research investigating the effects of these variables in the field and in combination is limited.

We need to consider impacts on weeds during research. There are 2 issues: a natural increase in weeds and deliberate/human introduction. Weed assessment tools predict potential spread and these include climate change modelling – could also have application for native species.

We do know that relatively small variations have significant impacts on plants, in particular on their reproductive ability. Plants that currently exist in warmer areas could establish in Tasmania in the future.

It follows that the most immediate threat posed by unassisted weed invasion is to those ecosystems with the most frequent turn over ie. those with the highest proportion of annual plants. Therefore grasslands and grassy woodlands are likely to see (are already seeing) changes in weed compositions and increased threat of weed invasion. Exotic grass species composition on the side of the road in the Midlands has changed and species are present that we had assumed would not survive here.

Research suggests that common flatweeds may not be favoured by climate change. However, they may well be replaced by exotic grass species. Assumptions regarding the level of disturbance required by some grass spp before they can invade native grasslands need to be revisited. Moreover, exotic grasses are frequently overlooked in vegetation surveys. We urgently need to gain a greater understanding of what grasses are already here, and what exotic grass species pose an imminent
threat due to their proximity. It is most likely that grasses currently restricted by temperature to warmer, drier temperate Australia pose the greatest risk.

Aquatic and semi-aquatic systems are also at risk due to the relatively high impact of increased temperatures. Again, we urgently need to understand the nature of exotic weed invasion in these systems in Tasmania.

Coastal ecosystems, as well as at risk directly from rising sea levels, are also likely to see increased coastal erosion which will increase the opportunity for weed invasion. Similarly, the likely increase in intense rainfall events and the increase in periods of little or no rainfall will create erosion-invasion opportunities in all ecosystems.

Stochastic events always have the potential to suddenly increase weed extent and impact. The combination of such events and CC is likely to increase the weed impact.

Human-assisted weed threats
Human attempts to mitigate environmental problems have frequently involved weed introductions (stream bank stabilisation, salinity). There will be an ongoing issue regarding the deliberate introduction of plant species that cope/thrive under altered climatic conditions. Risk assessment is an important tool in managing this threat, but it is only as good as the data that can be obtained, and it is only useful if their is political will to support the recommendations that come from it.

A related issue is that of biofuel production. Ideal biofuels share a number of characteristics with “ideal” weeds: fast growing, tough, self-sustaining, capable of reproduction/propagation etc. It is essential that plants proposed for biofuel production, particularly those that will require broadacre establishment (as opposed to wild harvesting of existing resources), are subject to rigorous weed risk assessment.

There is considerable threat to native ecosystems as the biofuel push turns away from food production areas/crops and seeks alternatives. This may include clearance for plantation establishment, and wide-ranging bio-prospecting.
IMPACTS OF CLIMATE CHANGE ON WILDLIFE DISEASE IN TASMANIA
Annie Philips
Wildlife Health Officer
Biodiversity Conservation Branch, DPIW

Wildlife Disease in Tasmania today
In the past 12 years Tasmania has experienced an unprecedented increase in the rate of emergence of several significant wildlife diseases such as Devil Facial Tumour Disease (DFTD) and Chytridiomycosis that threaten the Tasmanian devil and native frogs respectively. There has been significant research internationally that links the occurrence of Chytridiomycosis to climate change. In addition there has been a recent re-emergence of Psittacine Circoviral (Beak and Feather) Disease affecting Orange-bellied Parrots. Equine influenza recently emerged within Australia and Tasmania horse populations.

From the mid 1990’s until now 13 new wildlife diseases have emerged Australia-wide (Rose 2008), representing an unprecedented rate. This reflects a global trend. Why is this happening now? ......

- Infectious agents and diseases are part of the ecosystem and their introductions and emergence have contributed to ecosystem stability and resilience for millions of years via the processes of natural selection.

- Disease incidence and prevalence relate to dynamic associations among the host, the agent of disease, and the environment. Changes or disturbance in any or all of these factors can alter ecosystem processes and allow the expression or intrusion of significant wildlife diseases (Gillin et al. 2002).

- Factors contributing to the increased rate of disease emergence now in the Tasmanian context include – climate change, habitat destruction and fragmentation, introduced animals, urbanisation, change in agricultural practices including widespread chemical usage, water distribution / availability and international migration / trade (Rose 2008).

Wildlife disease expression that we are currently witnessing indicates that our ecosystem health is ailing and should be viewed as a warning signal.

Future impacts of climate change on wildlife disease expression
The health of wildlife and people are strongly interconnected - approximately 70% of significant new or emerging diseases affecting humans worldwide have a wild animal source (Environment Canada 2004).

In the first six months of 2003, diseases reservoired in wildlife were second only to war in claiming attention and causing expenditure by governments around the world (Environment Canada 2004). eg the global impact of West Nile Disease, Foot and Mouth, SARS, Avian influenza, HIV, Ebola etc.

The health of wildlife / people may be impacted by an increase in the frequency and severity of climate extremes (storms, floods, heat waves etc).

Climate change is likely to increase the distribution and biological behaviour of many arthropod vectors such as mosquitos and ticks (Daszak et al. 2000). This will increase disease transmission.

Increased temperature will increase the survival of some pathogens, increasing rates
of transmission, resulting in more disease outbreaks. Many diseases are expected to become more lethal or spread more readily as the earth warms (Epstein 2001).

Increased temperatures will result in physiological changes within the host, altering their susceptibility / immunity to disease.

- Warming will expand the range and increase the reproductive potential of rodents, increasing rodent-borne infectious diseases such as Leptospirosis and Hantavirus (McCarthy et al. 2001).
- Increased temperature, changes in precipitation, sea-level rise will alter habitat and therefore the dynamics of disease emergence.
- Flow on effects from increased disease emergence eg. Devil Facial Tumour Disease spread across mainland Tasmania and the associated decline in devil populations is creating an ecological niche that could be filled by introduced animals such as the fox and cat.
- Climate change is already causing species extinctions due to disease, climate driven epidemics are an immediate threat to biodiversity eg. Global decline / extinction crisis of amphibians due to Chytrid fungus (Pounds et al. 2006).

References


Epstein, P.R. Climate change and emerging infectious diseases. 2001. Microbes Infect. 3: 747-754.


Appendix 1. Agenda

Potential Impacts of Climate Change on Natural Systems & Natural Diversity
Thursday 22nd May (all day)
Riverview Room, Royal Tasmanian Botanical Gardens

AGENDA

9:00 am  Cuppa

9:15 am  Introduction – Louise Gilfedder (CPP, DPIW)

SESSION 1  OVERVIEW

9:30 am  Climate Science – Ian Barnes-Keoghan (BOM)

10:00 am  Implications of Climate Change for Australia’s Natural Reserve System – Michael Dunlop (CSIRO)

10:45 am  What is currently happening in Tasmania? – Alasdair Wells (SPP, DPIW)

10:55 am  Morning Tea

SESSION 2  VULNERABLE NATURAL VALUES IN TASMANIA

11:10 am  “Natural Diversity Values Roundtable” – Speakers proposed as follows (5 mins each)
   Ian Household – Geoheritage
   Tim Rudman – Impact of Coastline Change on Coastal Vegetation
   Phil Bell – Threatened Species and Communities
   Michael Driessen – World Heritage Area and Fauna
   Jennie Whinam – Alpine Ecosystems, Peatlands and Sub-antarctic Islands
   Stewart Blackhall – Waterbirds and Wetlands
   Drew Lee – Marine Ecosystems
   Bryce Graham – Freshwater Ecosystems
   Oberon Carter – Landscape Viability and the Protected Areas Network
   Other contributors?

12:00 pm  Natural Values – Group Discussion

12:20 pm  “Threats” – Speakers proposed as follows (5 mins each)
   Adrian Pyrke – Fire
   Andrew Crane – Weeds and use of plants for biofuels
   Tim Rudman – Plant Diseases
   Annie Phillips – Wildlife Management and Animal Diseases
   Other contributors?

12:50 pm  Other Threats and Threat Interactions – Group Discussion

1:00 pm  Lunch

SESSION 3  WORKSHOP (facilitated by Michael Dunlop)

2:00 pm  Issues arising from the morning sessions, including commonalities, differences, interactions, and the way forward

4:15 pm  Summary and future directions

4:30  Close
Implications of climate change for biodiversity and the Reserve System
Mike Dunlop

1. The changing conservation challenge
Current practice is often based on a static view of biodiversity:
- Focus on “what is currently there … forever”
- Focus on “ecological communities”
Substantial change to populations and ecosystems are inevitable …

The new challenge:
“Manage the change … to minimise the loss.”

Reassess expectations and adjust goals and guidelines
- Changing ecosystems, fluid communities, local extinctions OK?
- Global extinctions Not OK!

2. Cascade of impacts
Many changes.
Direct impacts and via interaction with other species and pressures.
Species will respond individually.
Key issues: distributions, abundances, interactions, ecosystem processes, threats.
Directional change, not cyclic.
Very hard to predict.
Manage (not stop) the impacts
Slow the climate change
Change our expectations

But what’s going to happen?
“Look, sound, smell different”

3. Drivers of climate change
- Change in relative abundance in situ
- A few rapid range expansions
- Gradual distribution changes
- Expansion of low density species
- In-filling from scattered/cryptic populations
- Little impact on composition
- Significant structure and function changes
- Mostly benign

Change in relative abundance in situ
- Expansion of low density species
- In-filling from scattered/cryptic populations
- Little impact on composition
- Significant structure and function changes
- Mostly benign

Gradual distribution changes
- Expansions from existing populations
- Species exclusion
- Distribution contractions
- Significant change in composition (turnover)
- Most/gradual change in structure and function

4. What’s going to happen to our biodiversity?
Three mental models
- The changing conservation challenge
  - “Manage the change to minimise the loss”
- Changing threats, including four “wicked threats”
  - Fire regimes, New species, Land use change, Altered hydrology
- Single species vs strategic management
- Coordinated broad-scale planning
- Development of the NRS
- “Excellent framework, but …”
- Management of reserves
- New information needs

Main objective
Dual goals for biodiversity conservation
1. Long-term: facilitate change, natural adaptation
2. Short-term: preserve vulnerable & valued elements

Examples:
- Habitat restoration
- Reserve establishment
- Environmental flows
- Fire regimes
- Grazing
- Connectedness

Understanding the changes and their implications will be challenging!
Connectivity and climate change

Join large patches of habitat... to facilitate movement of species. But...

Distributions and abundance affected by other species
There will be winners and losers
Who will benefit most from increased connectivity?
E.g. not alpine species!
“A fast track to extinction?”
Decreasing connectivity currently - a critical conservation tool.
Think about the consequences!

Average inter-fire interval from 500 year simulation — Current climate

Moderate change in climate

Planning

Information

Practical and conceptual issues

Strategic investment issues

Many conservation programs

Private conservation (revegetation, grazing, fencing)
Incentives, offsets
Pest and weed programs
Ex situ, translocations

Coordinate them...
Use a "bioregional scale" for anticipating change, planning, setting goals, assessing threats, status of biodiversity, and setting priorities...

With coordinated targets set for individual programs at different management scales...
And monitoring change & evaluate effectiveness at bioregional scale.

Where are species going to go?

North and inland??

Other region or local (cryptic) populations

Release" of sleeper populations - other region or local (cryptic) populations

Bioregional Framework reasonably robust...
...especially if augmented

Implications for planning and management

How they effect species: climate X threats
Which ones more important
Priorities, skills, information

Four "Wicked Threats": Environment X Society; no easy solutions

Fire regimes
Impacts and management
New species (species churn)
"National conservation"
Water resources
Species vs environmental uses
Land use change
Permanent pasture to cropping

A key role for landscape heterogeneity.
Threats will change...
...anticipate but also monitor and react

4. Coordinated and broad-scale conservation planning

Bioregional Framework (IBRA & CAR)

Contain a diversity of ecosystem types; provide opportunity for species

Process for capturing "comprehensiveness &" "representativeness"

Environmentally diverse – FUTURE

More species, more habitats — More

Ecological community planning

Wicked Threats

Needs a broad-scale approach

Resilience at three scales

Individual species
Can it survive?
Changing environment and threats
Somewhere to go
Intensive preservation??

Landscapes
Healthy ecosystems?
Species turnover and ecosystem change, OK
Diversity in the landscape
Landscape connectivity

Sociocultural systems
Balance maintained?
Ecosystem services delivered
Societal pressures contained
Institutional design

Needs a broad-scale approach

Refuges

Where are species going to go?

Near or far
Some places each species
Some as plant climate refuges
Some as refuges for species (churn)

Resilience of sleeper populations - gardens, roadsides, agriculture

Protecting refuges

Habitat diversity already targeted
Added priority
Contact or not
6. Challenge for reserve managers

Facing change
- Changing species, ecosystems, flood, fire, rainfall
- Conservation and visitor safety issues
- Threats: impacts and priorities
- Conservation task: “Manage the change to minimise the loss.”
  - “Facilitate change” & “ Preserve vulnerable species”

Old practice vs new realities
- Policies, guidelines
- Experience
- Information
- Institutional lags

Assessing impacts and adaptation
- Observing, monitoring and interpreting

Old “rules-of-thumb” less applicable
Managers will need institutional support

7. New information needs

Information about change and its implications
- Species, ecosystems, disturbance, threats
- Implications for conservation
- Societal preferences (some hard choices coming)
- Managing risks and uncertainty

Acquiring and sharing information
- Observing and monitoring (mental models, simple, designed)
- Research
  - Ecosystem processes, threats, as well as individual species
  - Modelling: species - 2nd generation needed; “toy assemblages”
  - Experiments
- Knowledge brokering & Partnerships: research, management, policy
  - Building awareness of climate change into core business of managing biodiversity

Analysing the impact of climate variability on natural systems
- Assessing sensitivities and types of impacts
- Mainstreaming climate and ecological change

Regional impacts assessment

Figure 2: Map of high-agro-climatic categories. Described in tables 1 and 2. Line within each climate category indicates HRS Hannahs in Table 2.

3. Potential Impacts of Climate Change on Tasmania’s Biodiversity

20. Summary

- Good understanding of potential impacts and implications
- The changing conservation challenge: “Manage the change to minimise the loss”
  - New twin goals: facilitate change & preserve vulnerable
- Changing threats: anticipable and react
  - “Wicked threats”: Fire regimes, New species, Land use change, Altered hydrology
- Single species vs strategic management
- Lack of accurate species predictions
- Coordinated & broad-scale planning
  - Bioregional scale for goals and monitoring
- Development of the NRS
  - “C” & “B” excellent design, but more needed
  - “A” challenging
- Management of reserves: big challenge
- Managers need help
- New information needs
  - Managing uncertainty
  - Mainstream climate impacts

Start NOW

21. Thank You

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Climate Change in Tasmania: Background
Ian Barnes-Keoghan

1. Some climate background

2. Hope to cover...
   - Some observations of change
   - The care needed when using observations
   - The global climate system
   - Climate models
   - The care needed with model outputs
   - Some climate projections

3. Global temperature and pirate numbers

4. Mean temperature anomalies


Projected temperature change over Tasmania

2030

2070

Some resources
Bureau of Meteorology
- www.bom.gov.au

Intergovernmental Panel on Climate Change
- www.ipcc.ch

Climate Change in Australia (2007)
- climatechangeinaustralia.gov.au

Climate Futures for Tasmania
- www.acecrc.org.au
# Appendix 3. List of workshop participants.

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Organization and Branch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Dunlop</td>
<td>Research Scientist</td>
<td>CSIRO Sustainable Ecosystems, Gungahlin, ACT</td>
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<td>Louise Gilfedder</td>
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<td>Conservation Policy and Planning Branch</td>
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<tr>
<td>Jennie Whinam</td>
<td>Senior Ecologist</td>
<td>Biodiversity Conservation Branch</td>
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<tr>
<td>John Harkin</td>
<td>Manager, Private Land Conservation Program</td>
<td>Conservation Policy and Planning Branch</td>
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<tr>
<td>Brooke Craven</td>
<td>Senior Policy Analyst</td>
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<td>Oberon Carter</td>
<td>Conservation Management Officer</td>
<td>Conservation Policy and Planning Branch</td>
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<tr>
<td>Felicity Faulkner</td>
<td>Spatial Analyst</td>
<td>Conservation Policy and Planning Branch</td>
</tr>
<tr>
<td>Ian Houshold</td>
<td>Geomorphologist (Karst)</td>
<td>Land Conservation Branch</td>
</tr>
<tr>
<td>Michael Askey-Doran</td>
<td>Principal Weed Management Officer</td>
<td>Land Conservation Branch</td>
</tr>
<tr>
<td>Phil Bell</td>
<td>Section Head (Threatened Species)</td>
<td>Biodiversity Conservation Branch</td>
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<tr>
<td>Mike Driessen</td>
<td>Zoologist (WHA)</td>
<td>Biodiversity Conservation Branch</td>
</tr>
<tr>
<td>Stewart Blackhall</td>
<td>Wildlife Biologist</td>
<td>Biodiversity Conservation Branch</td>
</tr>
<tr>
<td>Andrew Crane</td>
<td>Weed Management Planning Officer</td>
<td>Land Conservation Branch</td>
</tr>
<tr>
<td>Tim Rudman</td>
<td>Senior Vegetation Scientist</td>
<td>Biodiversity Conservation Branch</td>
</tr>
<tr>
<td>Annie Philips</td>
<td>Wildlife Health Officer</td>
<td>Biodiversity Conservation Branch</td>
</tr>
<tr>
<td>Declan McDonald</td>
<td>Section Leader (Sustainable Land Use)</td>
<td>Land Conservation Branch</td>
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<tr>
<td>Murray Root</td>
<td>Senior Conservation Investigations Officer</td>
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<tr>
<td>Sandra Whight</td>
<td>Fire Management Officer (Policy &amp; Assurance)</td>
<td>Department of Environment, Parks, Heritage and the Arts</td>
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<tr>
<td>Ben Clark</td>
<td>Visitor Research Officer</td>
<td>Department of Environment, Parks, Heritage and the Arts</td>
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<tr>
<td>Liza Fallon</td>
<td>Project Officer (SOE)</td>
<td>Resource Planning and Development Commission</td>
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<tr>
<td>Stephen Waight</td>
<td>Senior Project Officer (SOE)</td>
<td>Resource Planning and Development Commission</td>
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<tr>
<td>Part:</td>
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</tr>
<tr>
<td>Ian-Barnes Keoghan</td>
<td>Tasmania and Antarctica Climate Services</td>
<td>Centre</td>
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<td></td>
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<td>Bureau of Meteorology</td>
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Appendix 4
Participant Responses

What should the Tasmanian Government be doing for biodiversity conservation in terms of climate change?

“A world-first climate change policy that comprehensively and adequately addresses the potential impacts of climate change on biodiversity, which proposes a range of measures required to protect Tasmania’s unique natural assets.”

Reservation / protection of natural diversity
- Extend, protect and resource the Tasmanian reserve system to allow for broad biogeographic protection.
- Protect as wide a diversity of habitats as possible (and big ones).
- Protect a representative suite of wetland types with appropriate buffers.
- Protect large areas of representative / diverse habitat in each region.
- Incorporate climate change reserve design principles into broader planning. Identify those places most important, high heterogeneity. (Regardless of listing status). Focus on protection of large intact tracts.
- Assess landscapes for continuity / connectedness to develop a reserve system response to climate change.

Off-reserve
- Policy approach to sustainable land management on private land to support biodiversity outside the reserve system.
- Recognise biodiversity conservation as a priority in land-use change proposals.
- Develop a system for bringing biodiversity conservation on private land into the real economy. Make conservation of valued ecosystems etc pay.
- Ensure appropriate land management (agricultural, forest practices, planning) policies and codes of practice are in place that focus on geodiversity / biodiversity health as a matter of priority.
- Biodiversity inclusion in development planning improved in land-use and water development.
- Recognise the importance of water to all facets of natural diversity.
- Tasmanian government to put into place incentives to engage the community into looking after biodiversity.
• Protect soil biodiversity to maximise soil health, maintain and improve soil condition and optimise nutrient cycling and carbon sequestration.

Other Government Initiatives
• Tasmania is the logical location for a centre of excellence in protected area management, and to house a CRC for climate change and natural diversity management.

• Provide ongoing commitment to implement policy and planning objectives (ie. funding to enact outcomes and monitor the effectiveness of actions) => implementation.

• Government to separate itself from industries that result in massive emission production.

• Climate change and natural diversity is comprehensively incorporated into education package of secondary schools.
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