SUMMARY OF SESSION 2: CLIMATE CHANGE IMPACTS ON VICTORIA

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Gleadow, R.M. (2013) Summary of Session 2: climate change impacts on Victoria. *Proceedings of the Royal Society of Victoria* 125(1/2): 19–21. ISSN 0035-9211. Correspondence: ros.gleadow@monash.edu

TALKS in the third thread of the climate change symposium, *Impacts*, focused on possible impacts on sea level rises (Dr Kathleen McInnes), water resources (Dr Dasarath Jaya Jayasuriya), human health (Associate Professor Grant Blashki) and agriculture (Dr Leanne Webb) in the Victorian context. The series of articles here summarise the state of knowledge and provide an entry point for readers who want to delve further into the different impacts. We recognise that the consequences of climate change are so far reaching that the entire symposium could have been dedicated to each topic. This introduction highlights key points of each of the presentations. A short overview of the impact of climate change on biodiversity in Victoria is also included in this introduction, even though it was not able to be included in the symposium due to time constraints.

SEA LEVEL RISE AND COASTAL INUNDATION

Sea levels reflect the state of the climate system as a whole because much of the heating is stored in the ocean. Most of the increase in mean sea level in the 20th century was due to thermal expansion and melting glaciers (Lowe et al. 2010). However, the contribution of the melting of the Greenland and Antarctic ice sheets will increase over the present century, resulting in accelerated sea level rises. The impact of this rise is mostly felt during extreme weather events, when wave run-up results in inundation and erosion. The frequency of these inundation events in the future will increase markedly with increases in sea levels (McInnes et al. 2009). This will have a very great impact in Australia alone because there are approximately two million people living on land up to 1 m above the current mean sea level. The value of property and infrastructure in this zone is approximately Au$44 billion.

CITIES AND WATER

Climate models can be used to confidently predict broad trends in temperature and, to a lesser extent, precipitation on a global scale. Making predictions at a regional scale is more challenging and carries a higher degree of uncertainty (Braganza et al. 2013). Thus, it is difficult to be specific about what can be expected for the future in Victoria. It is important to collect good data on current trends so that any anomalies are quickly detected. As a state, we also need to be prepared for times of higher precipitation, changes in patterns of precipitation and changes in intensity and timing. Dr Jayasuriya (2013) demonstrated new tools and web interfaces that have been developed in the Bureau of Meteorology to enable better tracking of water resources. Forewarned is to be forearmed. These tools, already useful, have the potential to become vital in responding to vagaries in the climate in the future.

HEALTH

Global climate change is expected to impact human health on a global and regional scale. There are three levels of risk: (i) direct effects arising from an increasing frequency and intensity of heat waves; (ii) secondary changes mediated by climate change; and (iii) more diffuse consequences arising from economic decline and increased conflict over reductions in resources, such as food and water (McMichael 2013). There was a sharp increase in ambulance call-outs, hospitalisations and deaths during the heat waves in Victoria in February 2009 over several days, coinciding with the Black Saturday Bushfires (Blashki et al. 2011; Cordner et al. 2011). Such weather events are expected to become common in the future and will place pressure on Victoria's health services. One solution discussed at the Symposium was to create refuges for people to go to in heat waves, like evacuation centres, and to develop systems to warn people at risk when to attend such a centre (Blashki et al. 2011). Although there has been a significant decline in cold-related deaths in Victoria over the past few decades, which has been attributed to the increase in winter nighttime temperatures (Nicholls 2009), this is already outweighed by the overall increase in heat-related deaths.

Rising temperatures are correlated with an increase in infectious diseases, such as gastrointestinal infections (e.g. *Salmonella*), through the impact on food preservation (Blashki et al. 2011). Models predict changes in the distribution of mosquitoes and their impact on diseases, such as dengue fever. There may also be an increase in outbreaks of infectious diseases from climate-related disasters, such as flooding and infrastructure failures. Increases in food prices are already having an impact in some parts of the world through decreased nutrition and food security, particularly in the developing world. A possible effect of decreases in agricultural output in Victoria associated with climate change is an increase in mental health problems and a decrease in economic prosperity in Victoria's farming communities (Hansen et al. 2008; Blashki et al. 2011).

AGRICULTURE

It is likely that there will be major impacts from warming, changes in precipitation patterns and the direct effect of elevated carbon dioxide on crop plants. This will dictate changes in agricultural practice and the development of new crops (Gleadow et al. 2013). Lauren Rickards (2013), in her presentation, used grape vines as a case study. The timing of harvest and the number of days required for ripening were examined. There are other studies indicating that the composition of the wine grapes themselves will be altered by CO_2, water and temperature (Webb et al. 2011). Farmers are resilient and adapt to changes in climate on a year-to-year and season-to-season basis. What will almost certainly change is the risk matrix. Once a crop would have carried a known degree of risk of failure; now, risk will be either higher (e.g. barley, which depends on water) or lower (e.g. sorghum, which is heat tolerant).

BIODIVERSITY

The term 'food web' captures the sense of interactions between organisms in natural ecosystems. Perturbing one aspect has ramifications for others sections. The distribution of species in Victoria in the future is likely to be impacted by changes in temperature, fire frequency and intensity (Gleadow & Narayan 2007; Banks et al. 2011; Hoffmann & Sgro 2011), as well as the frequency and intensity of drought (Thomson et al. 2012). Changes in CO_2 concentrations can also drive changes in the ability of plants, such as eucalypts, to support wildlife and in the types of organisms in the soil (Cavagnaro et al. 2011). Plants and animals have limited options. Evolution is on a longer scale, although some smaller organisms, such as fruit flies, with a short life cycle, may be able to adapt (Hoffmann & Sgro 2011). A more feasible option is for some organisms to move to new areas where the climate is similar to their historical regions. A simple example is for plants to move from areas of low elevation to areas of high elevation. The difficulty is that long-lived species, such as trees, will only move slowly. All organisms face the problem that the location of their new habitat may not be available; for example, it may be farmland, a reserve or a part of the built environment. Rising temperature and changes in precipitation will make the future of natural ecosystems even more precarious.

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