NSW GOVERNMENT Office of Environment & Heritage

AdaptNSW

Urban Heat
Climate Change Impact Snapshot

Overview of impacts of land-use changes on **Sydney's** temperatures

Climate change is projected to increase the temperatures in Sydney. Maximum temperatures are projected to increase by 0.7°C by 2030 and up to 1.9°C by 2070.

- The land-use changes planned for Sydney to accommodate growing populations, jobs and housing demands have the potential to lead to further increases in urban temperatures.

- The converting of areas in the north-west and south-west of Sydney from forest and grasslands to new urban development may double the projected temperature increases from climate change in the near future.

- The changes in temperature due to urban development vary by season, with the larges changes seen in summer. The highest temperature increase from new urban developments will occur on summer afternoons and evenings.

- Different land-use changes have different effects on temperature during the day. In the near future in summer between 1.00pm and 9.00pm, grasslands converted to medium density urban areas are projected to increase temperatures by 0.48–0.91°C, while high density urban land which is converted to Sydney CBD density will decrease temperatures by 0.45–0.53°C at the same time.

- The CBD and inner suburbs may see a small decrease in temperature due to shading and the influence of the sea breeze.

Climate Change Impact Snapshot

Climate Change Impact Research Program (CCIRP)

This impact report is part of the NSW Climate Change Impact Research Program (CCIRP). The CCIRP aims to understand the biophysical impacts of climate change in NSW using the climate change projections from the NSW and ACT Regional Climate Modelling (NARCliM) project. CCIRP is designed to ensure the research delivered meets the information needs of the NSW community. The CCIRP program is ongoing and will continue to provide updated information on the likely impacts of climate change in NSW.

NSW and ACT Regional Climate Modelling Project (NARCliM)

The climate change projections in this impact snapshot are from the NSW and ACT Regional Climate Modelling (NARCliM) project. NARCliM is a multi-agency research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW. NSW Government funding comes from the Office of Environment and Heritage (OEH), Sydney Catchment Authority, Sydney Water, Hunter Water, NSW Office of Water, Transport for NSW and Department of Primary Industries.

The NARCliM project has produced a suite of 12 regional climate projections for south-east Australia spanning the range of likely future changes in climate. NARCliM is explicitly designed to sample a large range of possible future climates. The NARCliM project used a "business as usual" scenario (IPCC A2 scenario) consistent with international modelling approaches. This scenario assumes global development and population continues along current trajectories.

Future climate change projections are compared to the baseline modelled climate (1990–2009). Interpreting climate projections can be challenging due to the complexities of our climate systems. 'Model agreement', that is, the number of models that agree on the direction of change (for example increasing or decreasing rainfall) is used to determine the confidence in the projected changes. The more models that agree, the greater the confidence in the direction of change.

NARCliM has produced projections for:

1. The **near future** (2020-2039): these projections represent the best estimate of future climate by **2030**, even with significant global mitigation measures.
2. The **far future** (2060-2079): these projections are more sensitive to changes in global emissions but still represent the current best estimate of our future climate by **2070**.

Go to climatechange.environment.nsw.gov.au for more information on the modelling project, methods and technical reports.

Impact Science Technical Reports

The Climate Change Impact Snapshot reports are based on detailed technical reports. The 'Impacts of land-use change on Sydney's future temperatures" Technical Report details the results of the impact science research and can be accessed from the AdaptNSW website: climatechange.environment.nsw.gov.au

The snapshots provide descriptions of climate change projections for two future 20-year periods: near future or 2030, and far future or 2070 and represent the average of the two 20 year periods 2020-2039 and 2060-2079.

The maps in the snapshots represent an **average** of 12 models. The full range of variability is discussed in the technical report.

Help on how to interpret the maps and graphs in this report is provided in Appendix 1.

This snapshot focusses on the impacts of development and land-use change by 2036 on urban temperature.

Introduction

Cities create their own microclimates by influencing the surrounding atmosphere and interacting with climate processes. The most striking characteristic of an urban microclimate is the urban heat island (UHI) effect. The UHI effect represents higher air temperatures in urban areas than those in surrounding non-urban areas (Taha 1997). In Sydney, morning summer surface temperatures in treeless urban areas are on average 12.8°C higher than vegetated non-urban areas (Adams & Smith 2014).

Urban microclimates are also influenced by density, building height and vegetation cover. The influence of the Sydney Greater Metropolitan Area urban footprint on the microclimate is expected to increase as more of the NSW population resides in urban areas. According to Taylor et al. (2014), in the years 2011–31 Sydney's population is expected to rise by over 1.5 million (37%). This population increase is expected to lead to an additional 600,000 households (40%).

In the Plan for Growing Sydney (2014) (planning.nsw.gov.au) the requisite housing, jobs and services will be accomodated through urbanisation in the south-west and north western regions, and densification of existing suburbs.

The impact of planned urban expansion and increased density on Sydney's urban temperatures by 2030 was assessed. The results of this assessment are presented here. For more information on the methods see the Urban Heat Technical Report (climatechange.environment.nsw.gov.au).

Projected regional climate changes

In 2014 climate change projections were released for the Sydney Metropolitan Region as part of the NSW and ACT Regional Climate Model (NARCliM) project.

Climate change projections are for the near future (2030) and far future (2070), compared to the baseline climate (1990–2009). The projections are based on simulations from a suite of twelve climate models run to provide detailed future climate information for NSW and the ACT.

Temperature is the most reliable indicator of climate change. Across NSW all of the models agree that average, minimum and maximum temperatures are all increasing.

Temperature

Sydney is expected to experience an increase in all temperature variables (average, maximum and minimum) from climate change (Figure 1a to c). Maximum temperatures are projected to increase by 0.7°C by 2030 and by up to 1.9°C by 2070. The greatest change in maximum temperatures is projected to occur during spring, increasing by up to 2.2°C by 2070.

Increased maximum temperatures are known to impact human health through heat stress and increasing the number of heatwave events.

Minimum temperatures are projected to increase by 0.6°C by 2030 up to 2°C by 2070. Increased overnight temperatures (minimum temperatures) can have a considerable effect on human health. These increases are projected to occur across the region.

The Metropolitan Sydney Region is also expected to experience more hot days in the near future and in the far future.

The greatest increase in the near future is projected for Western Sydney and the Hawkesbury with an additional 5–10 hot days by 2030 (Figure 2).

Temperature

Summary

Maximum temperatures are projected to increase in the near future by 0.7°C

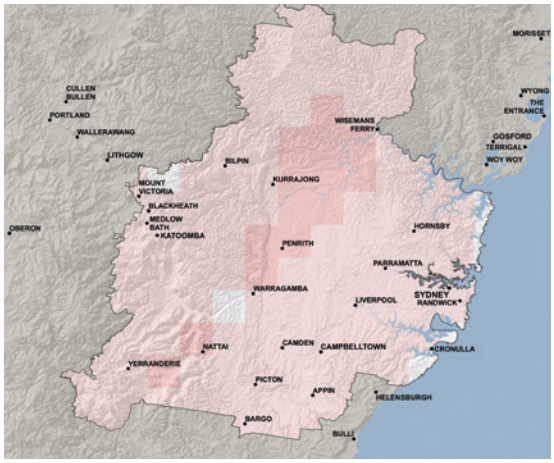
Maximum temperatures are projected to increase in the far future by 1.9°C

Minimum temperatures are projected to increase by near future by 0.6°C

Minimum temperatures are projected to increase by far future by 2.0°C

There are projected to be more hot days and fewer cold nights

Near future change in days per year above 35°C



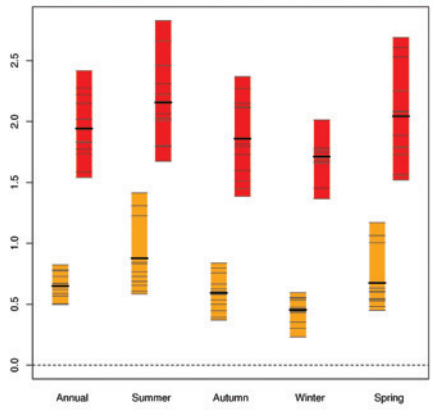
Metropolitan Sydney

Change in annual average number of days with temperatures greater than 35°C

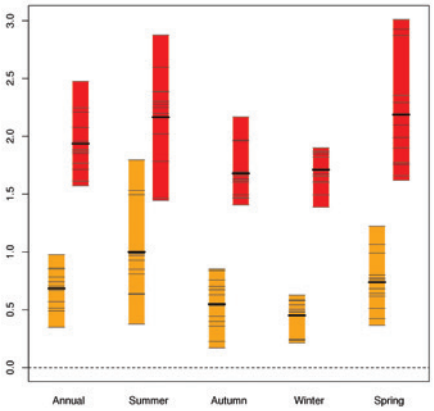
- >40
- 30 – 40
- 20 – 30
- 10 – 20
- 5 – 10
- 1 – 5
- 0 – 1

Figure 2: Near future (2020–2039) projected changes in the number of days per year with maximum temperatures above 35°C.

a) Average air temperature



b) Daily maximum temperature



c) Daily minimum temperature

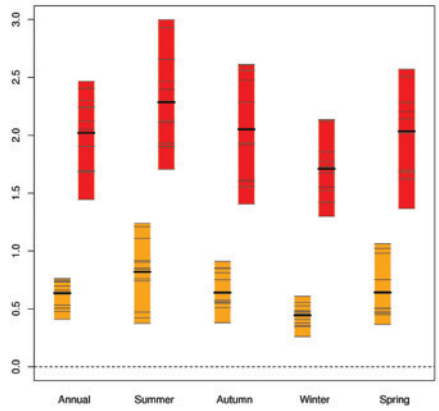


Figure 1: Projected air temperature changes for the Metropolitan Sydney Region, annually and by season (2030 yellow; 2070 red): a) average, b) daily maximum, and c) daily minimum. (Appendix 1 provides help with how to read and interpret these graphs).

Planned land-use changes

Over 11% or 734 km^2 of Sydney is planned to have changes in land-use by 2036 (Figure 3). The types of land-use changes include:

- forest to low or higher density urban
- grasslands to low density urban
- grasslands to medium or higher density urban
- low density urban to medium or higher density urban
- medium density urban to high or CBD density urban
- high density urban to CBD density urban
- industrial/commercial to low density urban.

The two largest changes will be the conversion of grasslands to low density urban (229 km^2) and low density to medium or higher density urban (306 km^2).

Conversion of low density urban to higher density urban areas is projected for the outskirts of the existing urban extent and along major arterial roads (M4 and M5). The majority of changes from grasslands to low density urban will occur in the suburban development regions of the south-west and north-west of Sydney. Changes from forest to low or higher density urban are projected to occur in areas in the Blue Mountains in the west and across most of the north of Sydney.

Changes from medium density urban to high or CBD density urban will occur across much of the current urban area, up to 40 km west of the Sydney CBD in large town centres such as Parramatta, Hornsby, Liverpool and Blacktown. High density urban increases to CBD density urban will occur around the Sydney CBD and along the coast.

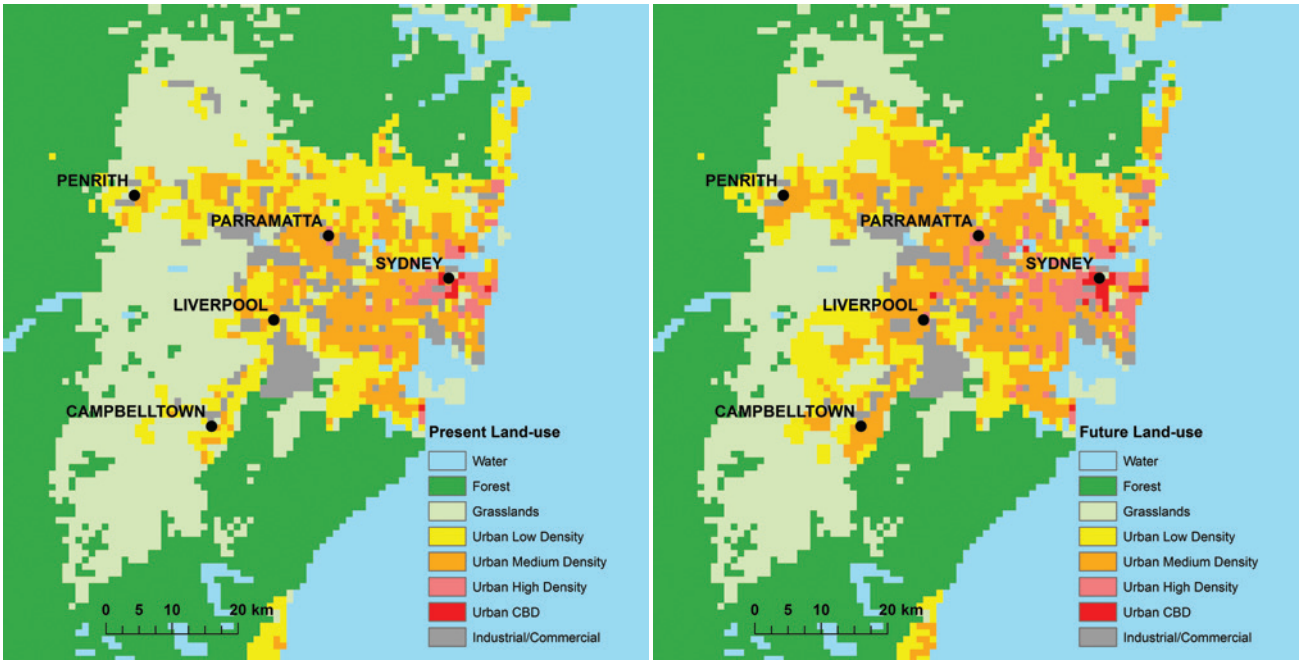


Figure 3: The present and near future (2036) land use for Sydney's urban region

Impacts of land-use changes on temperature

The potential impact of land-use change on temperatures is in addition to the temperature increases caused by climate change.

On average, annual temperatures will increase in areas which are converted from forest or grasslands to urban and from low urban density to higher urban density (Figure 4). The increased temperatures are caused by the introduction of urban structures and infrastructure materials and the removal of vegetation.

Urban structures and materials change the shape of the land and the way the surface interacts with sunlight, such as the amount of sunlight reflected, absorbed and re-emitted as heat. Vegetation can decrease temperatures by providing shading and evaporative cooling. This benefit is lost when vegetation is removed.

Changes from industrial/commercial to low density urban will cause a negligible increase in temperatures. Increasing the density of medium or higher density urban areas is projected to result in lower average temperatures. Such temperature decreases are potentially due to the combination of shading from increased building height and the effects of afternoon coastal sea breezes.

Sea breezes are caused by high land temperatures and cool sea temperatures. The greater the difference in temperature the stronger the sea breeze. Higher morning temperatures caused by increased urban density could potentially increase the strength of the afternoon sea breeze and in turn decrease afternoon temperatures.

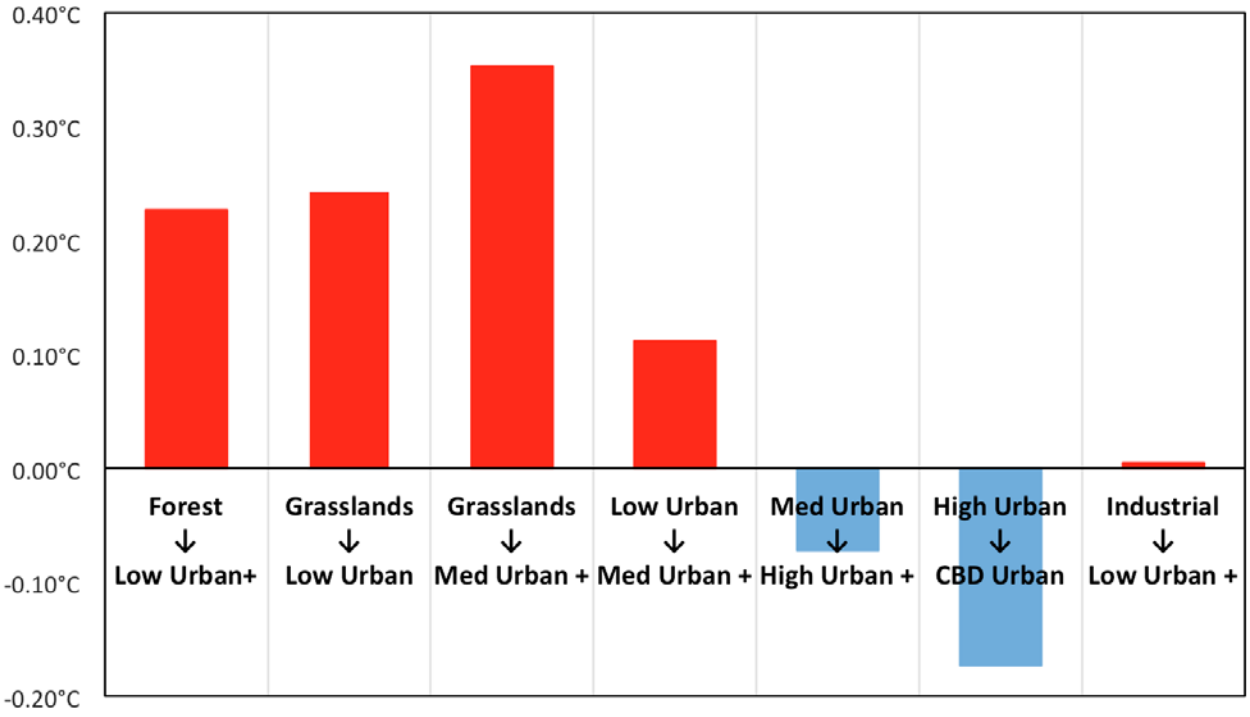


Figure 4: Annual average daily temperature changes caused by land-use change in the near future

Impacts of land-use changes on temperature

Daily trends

Each land-use conversion will influence temperature change differently throughout the day (Figure 5), with temperature changes also varying with proximity to the coast (Figure 6).

There is little impact on daily temperatures across the different land-use types between the hours of 1.00 am and 6.00 am.

In the morning much of Sydney is projected to experience increased temperatures as a result of land-use changes. The largest increases in temperature are found where forest is converted to urban, industrial/commercial is converted to low density urban and low density urban is converted to higher density urban.

By the afternoon, temperature changes are further increased in areas where urban land-use has replaced forest and grasslands. Large areas of Sydney to the south-west and north-west are projected to experience temperature increases by 1–1.4°C due to these land-use changes in the near future.

Temperatures increases for forests and grasslands converted to urban areas are projected to persist through the night, with the effect reducing between 10 pm and midnight.

During this time, a decrease in temperature is projected for coastal areas where medium or higher density urban areas are projected to increase in density. This decrease may be potentially due to strengthening sea breeze and is therefore greatest in the afternoon.

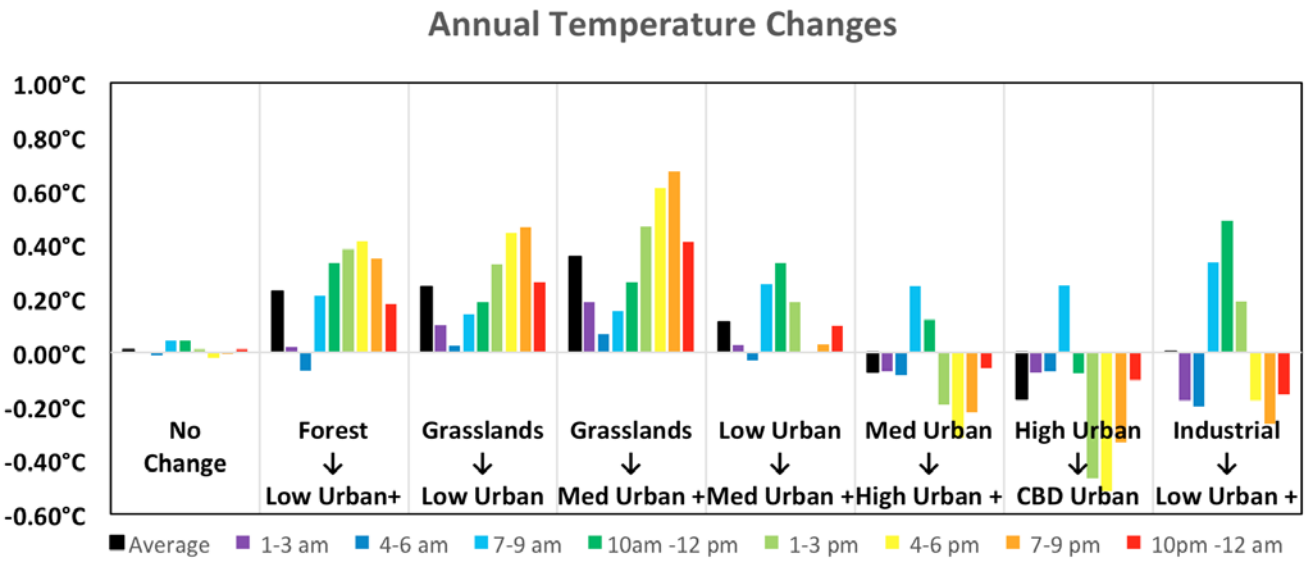
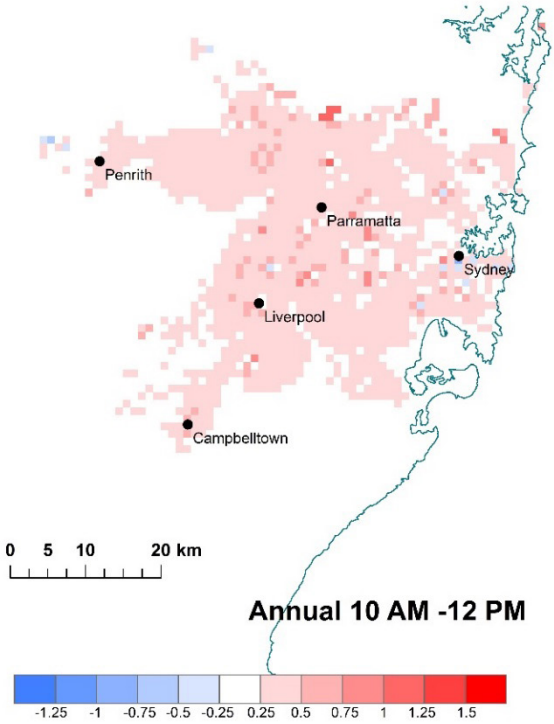


Figure 5: Annual temperature changes for each projected land-use change



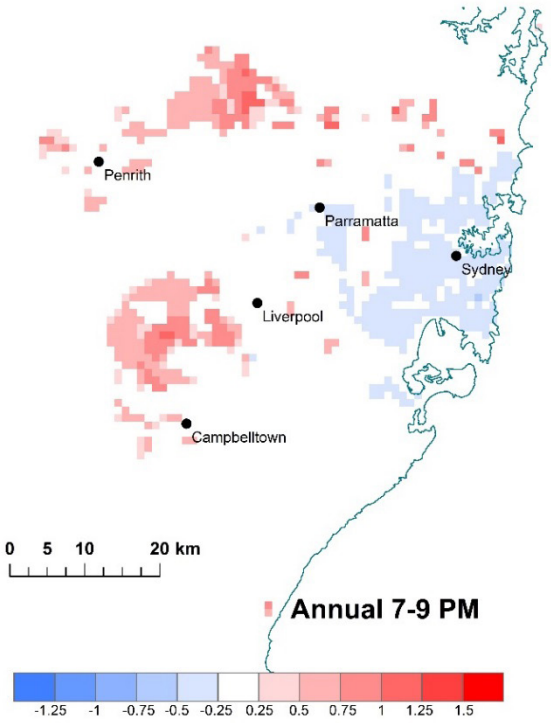


Figure 6: Largest changes in annual average temperatures (°C)

Seasonal trends

Temperature changes due to land-use change follow a similar pattern throughout each season. However the magnitude of the change in temperature is dependent on the season (Figures 7 to 10).

In the near future the largest changes for each of the land-use change types occurs in summer (Figure 8), while winter sees the smallest change (Figure 10).

Future land use changes in Sydney have the potential to enhance the projected temperature increases caused by climate change. The greatest temperature increases are projected to occur in areas converted from forest and grasslands to new urban developments, such as is planned to occur in large areas in the north-west and south-west. These land-use changes are projected to more than double the projected temperature increases projected from climate change.

For new urban developments, the greatest increase in temperature will occur on summer afternoons and, on average, last late into the night. The persistence of higher temperatures is due to the heat emitted by urban structures. For example, higher temperatures will remain throughout the 24 hour period for large portions of the southwest and northwest during summer.

Impacts of land-use changes on temperature

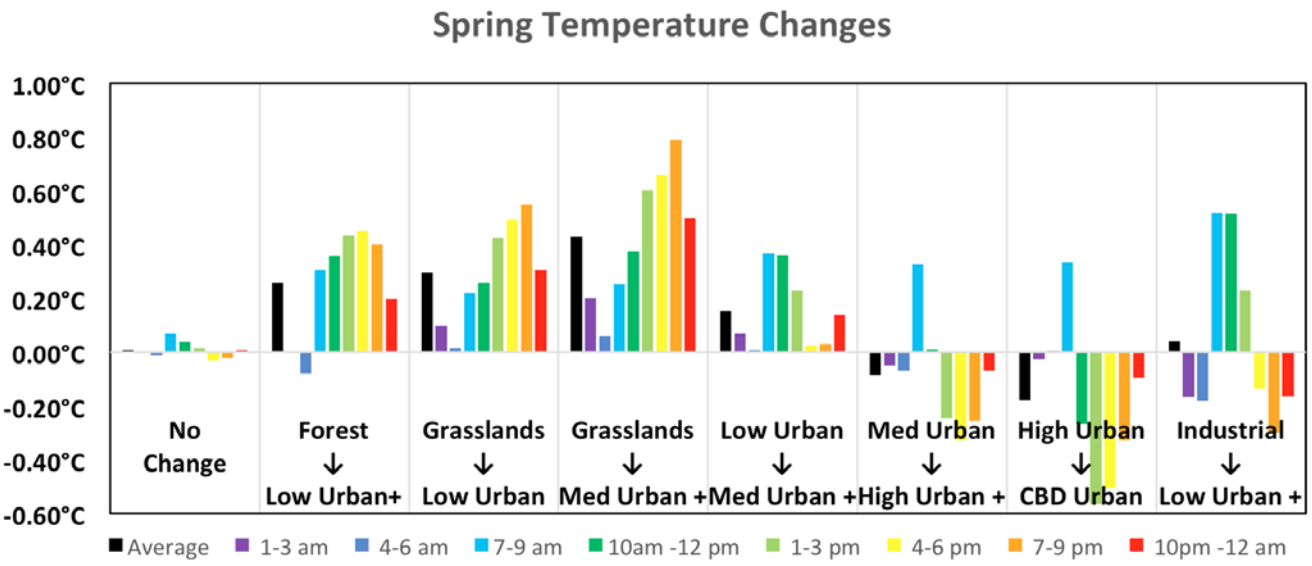


Figure 7: Temperature changes in spring for each projected land-use change

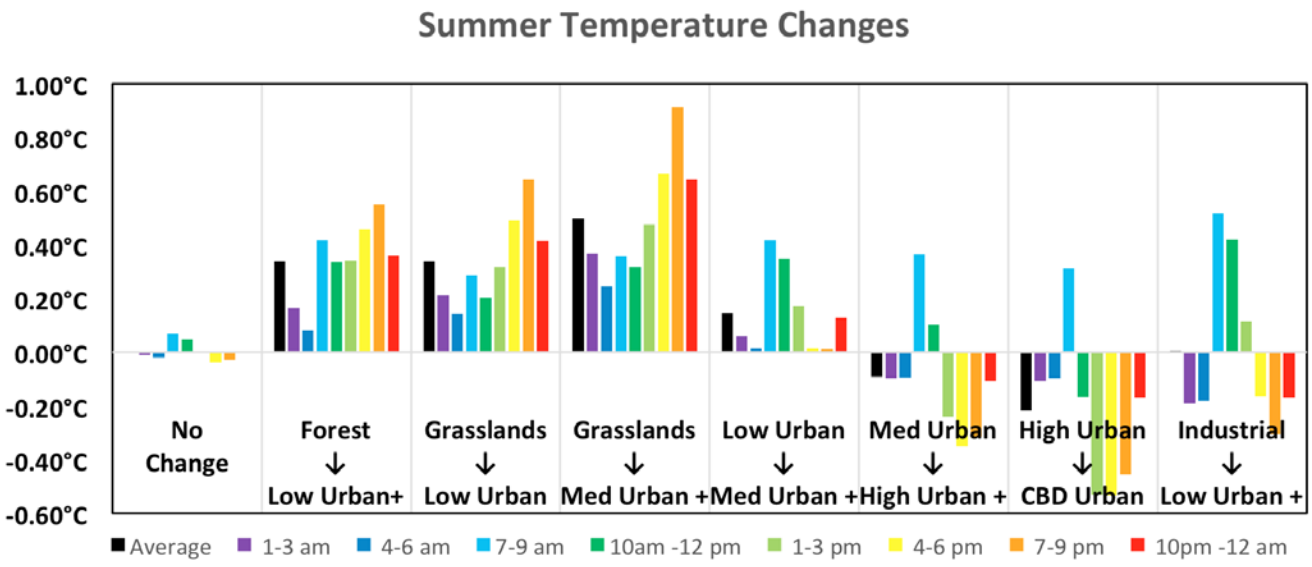


Figure 8: Temperature changes in summer for each projected land-use change

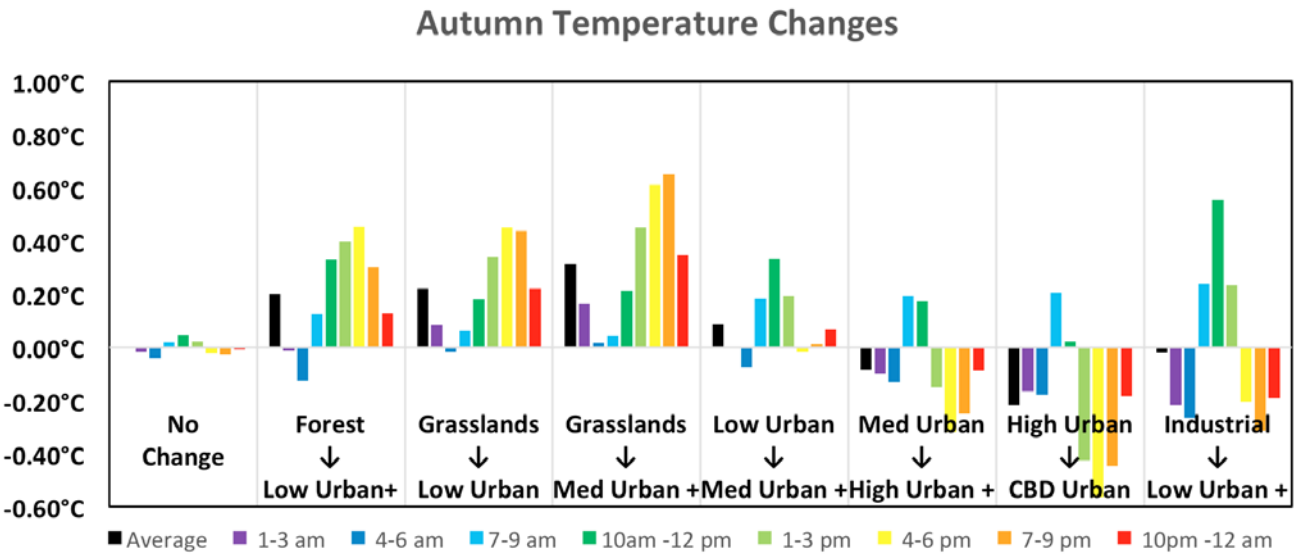


Figure 9: Temperature changes in autumn for each projected land-use change

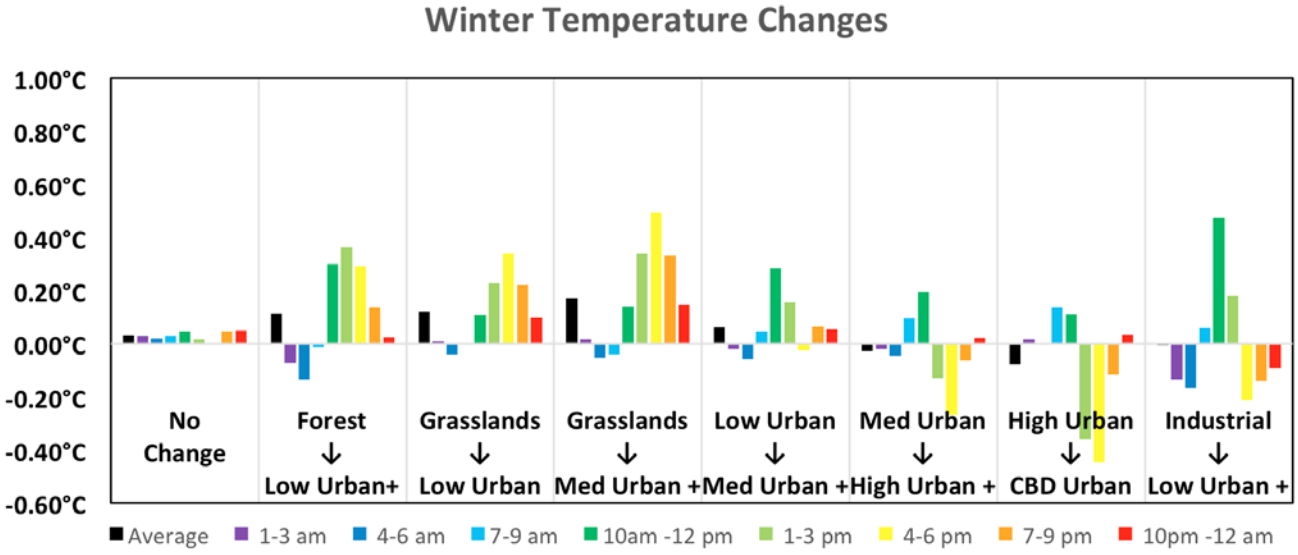
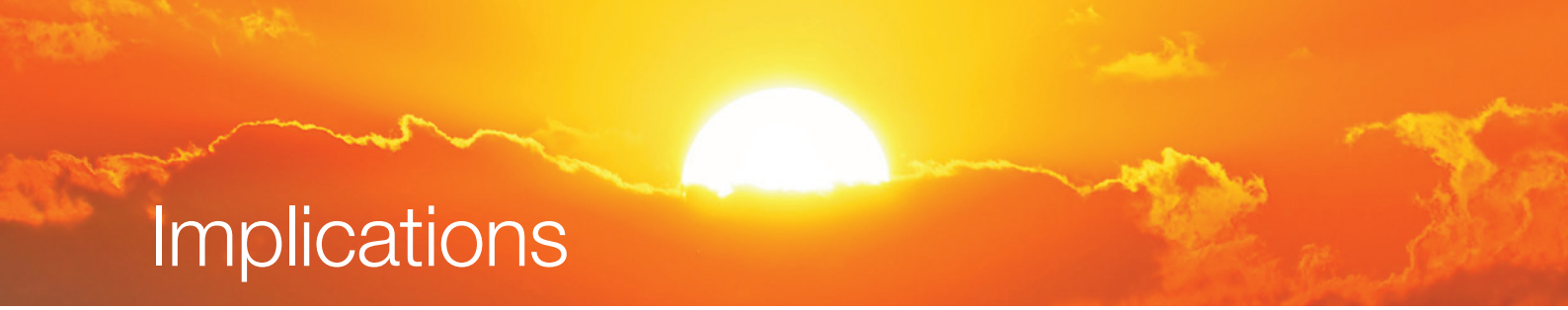


Figure 10: Temperature changes in winter for each projected land-use change



Implications

This research demonstrates how urban development can affect local climates. The combined temperature increases from climate change and urban land-use change will produce a range of impacts on local communities; including risks to health, infrastructure services, productivity, increased energy demand and air quality.

Almost 90 percent of NSW residents live in urban settings/areas. Implementing strategies to minimise local temperature impacts in cities and towns is increasingly important.

Addressing heat associated with climate change and urbanisation will require greater consideration of adaptive urban design and development. Integrating vegetated, permeable and reflective surfaces into the built environment, and protecting existing vegetation can provide services such as shade, cooling, fresh air, reduced energy use and wind speeds, stormwater regulation, biodiversity habitat and connectivity. There is growing evidence that urban vegetation can also improve human heath, extend life spans, reduce violence and vandalism, and improved cognitive development in children (Dadvand et al, 2015).

The NSW Government has released two initiatives that will assist in minimising the impacts of heat on urban communities;

1: The Urban Green Cover Technical Guidelines (OEH) to provide practical advice on best practice. The purpose of these guidelines is to increase the resilience of NSW settlements and communities to climate change, specifically to increasing temperatures in urban settings. See Green Cover at climatechange.environment.nsw.gov.au

2: The Metropolitan Green Grid (DPE) an open space and natural areas network that connects homes, transport, jobs and recreation opportunities across Sydney.

Appendix 1 Guide to reading the maps and graphs

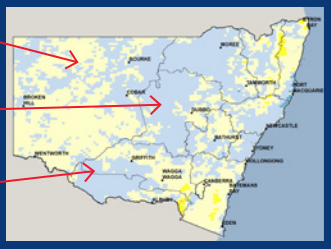
This document contains maps and bar graphs of the climate change projections, which are used to present the twelve model outputs as a central estimate calculated by averaging the results from the twelve models. The bar graphs show future projections averaged across the entire region and are not representative of any particular location within the region. For more detailed spatial information, maps are presented showing the central estimates of future projections. Below is information on what is displayed in the bar graphs and maps.

How to read the maps

The map displays modelled data in grids across NSW.

The colour of each grid is the AVERAGE of 12 models for that grid.

The State is divided into NSW State Planning Regions.



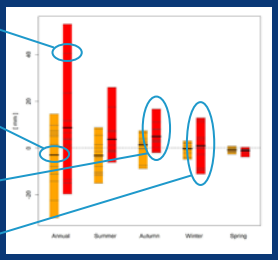
How to read the bar graphs

The thin grey lines are the **individual models**. There are 12 thin bars for each bar.

The thick line is the **average of all 12 models** for NSW.

The length of the bar shows the **spread of the 12 model values** for NSW.

Each bar represents the **average for NSW**. They do not represent a single location.



Note: The yellow bars represent near future scenarios (2020–2039), while the red bars represent far future scenarios (2060–2079).

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