Soil Erosion
Climate Change Impact Snapshot

Overview of Rainfall Erosivity and Hillslope Erosion

NSW is projected to undergo an increase in soil erosion and erosivity (rainfall which causes erosion) in both the near and far future.

- The areas most affected will be those with already high erosion risk, such as the mountainous regions of the Great Dividing Range especially in the high risk regions of Central Coast, North Coast and Hunter.
- There are areas with significant projected erosion impacts, for example up to 195 t/ha/yr in the Hunter region, highlighting the importance of groundcover maintenance and soil management in these regions.
- Although erosivity is projected to increase greatly in some western parts of the state (e.g. >70% increase near Broken Hill and Bourke) it is unlikely this will have any significant impact on erosion due to the flat terrain and low erosion rates.
- Changes in erosion can have significant implications for natural assets, agricultural lands and water quality.

Front cover photograph: Mulga (Acacia aneura) in red sand, outback Australia. Copyright: Ashley Whitworth. Page 2: World heritage area Lamington National Park, Elabana falls in the Gold Coast hinterland on the New South Wales border. Copyright: Rob D. Page 5: Colorful and unique rock formation in Bouddi National Park on the east coast of Australia. Copyright: ausnewsde. Page 6: Mungo National Park, New South Wales. Copyright: Marc Witte. Page 7: Leura falls upper section, Blue Mountains, Australia. Copyright: Greg Brave. Page 8: Massive rock faces in the Wollomombi Gorge, New South Wales. Copyright: Milosz_M. Page 9: Mulga (Acacia aneura) in red sand, outback Australia. Copyright: Ashley Whitworth. Page 10: Australian Landscape Copyright: A Periam Photography. Page 11: Perisher Blue, Snowy Mountains, New South Wales. Copyright: Leelakajonkij. Page 12: Green grass meadow in the Australian countryside. Copyright: Vaclav Mach.

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 'Climate change impacts on rainfall erosivity and hillslope erosion in New South Wales' 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.

Introduction

The NSW climate is highly variable, ranging from subtropical with summer-dominated rainfall in the north-east, to temperate climates with uniform or moderately winter-dominated rainfall in the south of the State. These variations in rainfall affect soil conservation, food security, and natural resources management. Rainfall erosivity is one of the main drivers for soil erosion and land degradation (Yang & Yu 2015).

Rainfall erosivity is a measure of the ability of rainfall to cause erosion and is largely a function of both the amount of rainfall and the intensity of rainfall (Renard et al. 1997). In this report rainfall erosivity is a measure of multiple factors relating to slope and slope-length (Yang 2015), soil erodibility, groundcover (Yang 2014) and soil conservation practices, to project the average annual soil loss per unit area in tonnes per hectare per year (t/ha/yr).

Rainfall erosivity is important as it is the driving force of erosion in all three steps of erosion by water (Figure 1). Hillslope erosion (including sheet and rill erosion), is the removal of material from surface soil by raindrop impact and surface flow. It results in loss of the finest soil particles that contain most of the available nutrients and organic matter in the soil.

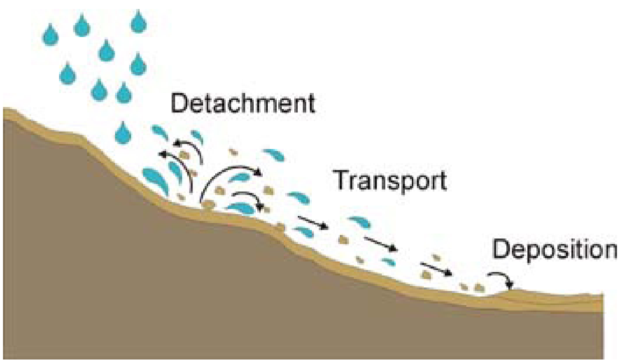


Figure 1: Rainfall erosivity impacts all three steps of erosion by water

The risk of soil erosion varies across NSW primarily due to the terrain, for example, steep terrains have high erosion risk while flat terrains have low erosion risk. Storm events also play an important part in the amount of soil erosion. Soil erosion also varies depending on the land-use, with different erosion risks between agricultural lands and conservation reserves (Rosewell 1993). Rates of soil erosion also differ after an erosion event.

In this report we discuss the changes to erosivity from projected climate change, the impact of changes to erosivity on hillslope erosion and the implications for different land-uses across NSW.

Rainfall erosivity

Current distribution

Rainfall erosivity varies with the patterns of rainfall across the state. In general, rainfall erosivity increases from the west towards the Great Dividing Range and the coast and, from south to north (Figure 2). These trends are due to the coastal influence of storm events and the influence of the Great Dividing Range on rainfall. Erosivity also varies from season to season and is higher in summer and lower in winter (Yang & Yu 2015) (Figure 3).

Mean monthly rainfall erosivity [MJ.mm/(ha.hr.month)]

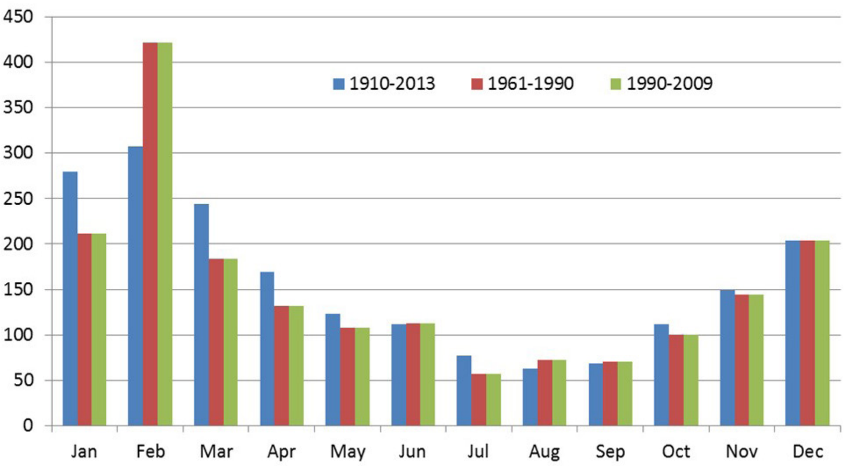


Figure 3: Monthly mean rainfall erosivity in three historical periods calculated from BoM data

Rainfall erosivity

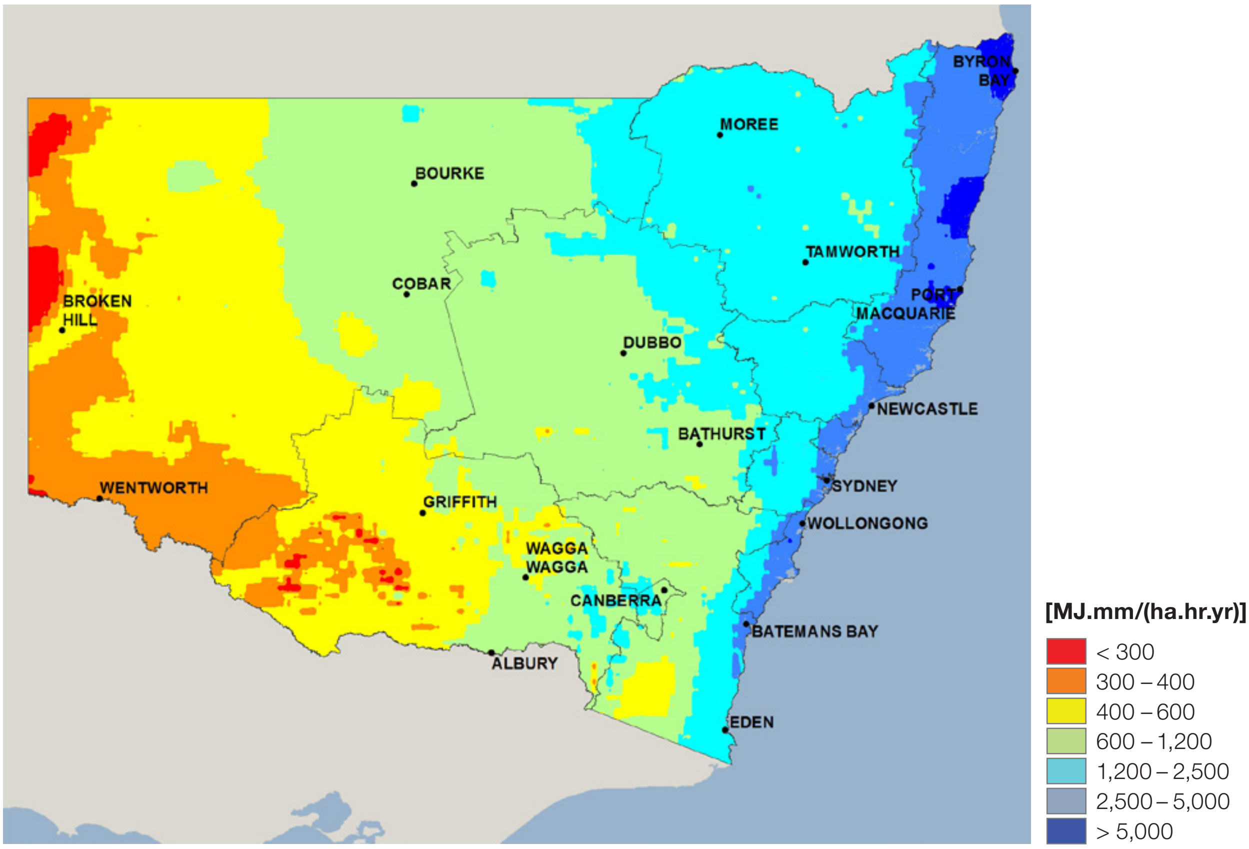


Figure 2: Mean annual rainfall erosivity in baseline (1990–2009) period calculated from BoM historical data

Future changes in erosivity

NSW is projected to experience an increase in mean annual rainfall erosivity of 7% in the near future (7/12 models agree) and 19% in the far future (all models agree) (Figure 4).

The seasonal changes to erosivity reflect the changes in projected rainfall. The majority of models agree that erosivity will increase in summer for both the near future (8/12) and the far future (12/12) (Figure 4). For autumn the majority of models project an average increase across the state in the near future (11/12) and the far future (11/12).

Changes to winter and spring erosivity are less clear due to the complex nature of the projected changes in rainfall in those seasons.

The seasonal distribution of rainfall erosivity will have impacts on hillslope erosion. The results suggest that the projected changes in seasonality of rainfall erosivity alone could cause a sevenfold increase in soil loss, even if the rainfall amount and intensity are the same.

Rainfall erosivity will continue to vary across NSW and changes in rainfall erosivity will also vary from region to region (Figures 5 to 8). The greatest increases in risk (>70% change) appear around Broken Hill and the Far West. Though the relative changes are high there is little impact on hillslope erosion and historically these areas do not experience significant water erosion (less than 0.1 t/ha/yr) due to relatively flat terrain. Even if the rainfall erosivity in these areas increases by 90% in the future, the actual hillslope erosion would still only be 0.19 t/ha/yr, considerably lower than along the coast and the ranges.

Importantly areas along the coast and the ranges are projected to experience up to a 40% increase in erosivity in the near and far futures, especially in summer and autumn (Figure 5 to 8). Erosivity is also projected to increase considerably along the Central Coast during winter (20–30%).

In winter the south and north coasts are projected to have a decrease in rainfall erosivity in the near future and far future. This is due to a projected decrease in winter rainfall in these areas.

These increases in erosivity may have implications for water quality, agricultural productivity and biodiversity. It is important to maintain good groundcover in these areas, otherwise there will be a significant increase in erosion risk.

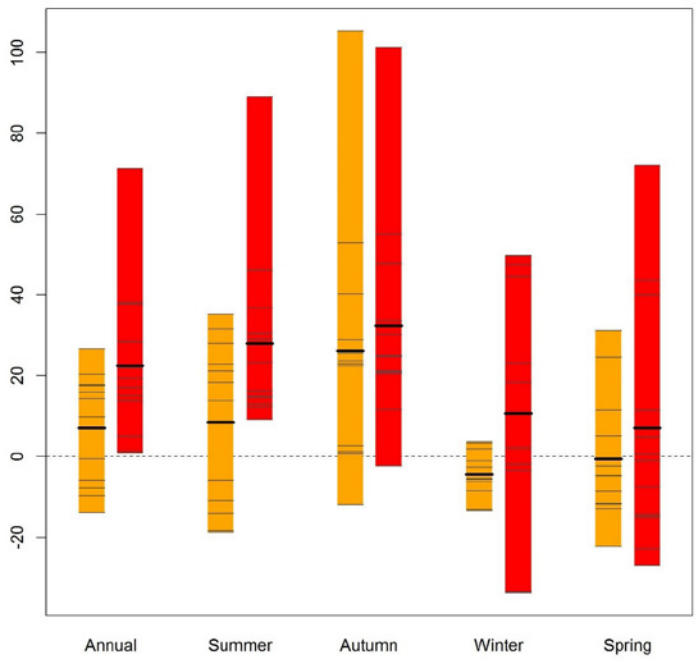


Figure 4: Future seasonal and annual changes (%) compared with baseline and individual models

Future changes in erosivity

Near future

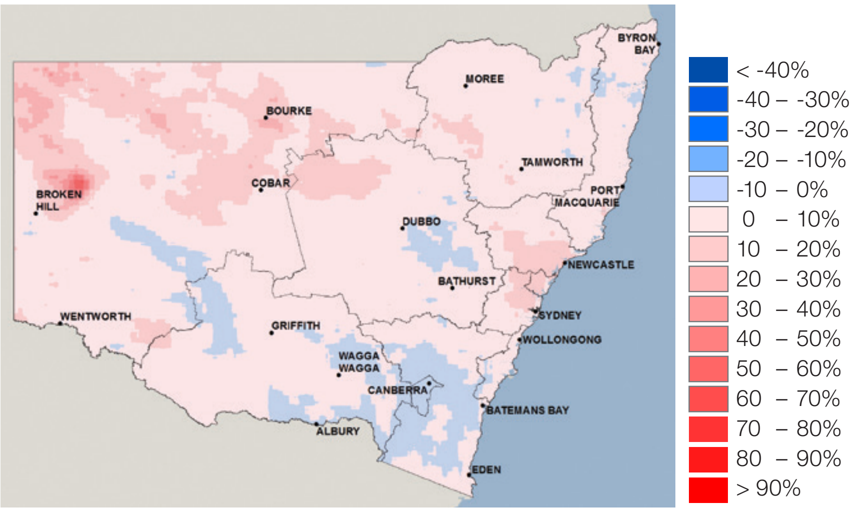


Figure 5: The percent change (%) in rainfall erosivity in the near future (2020–2039) compared with the present (1990-2009)

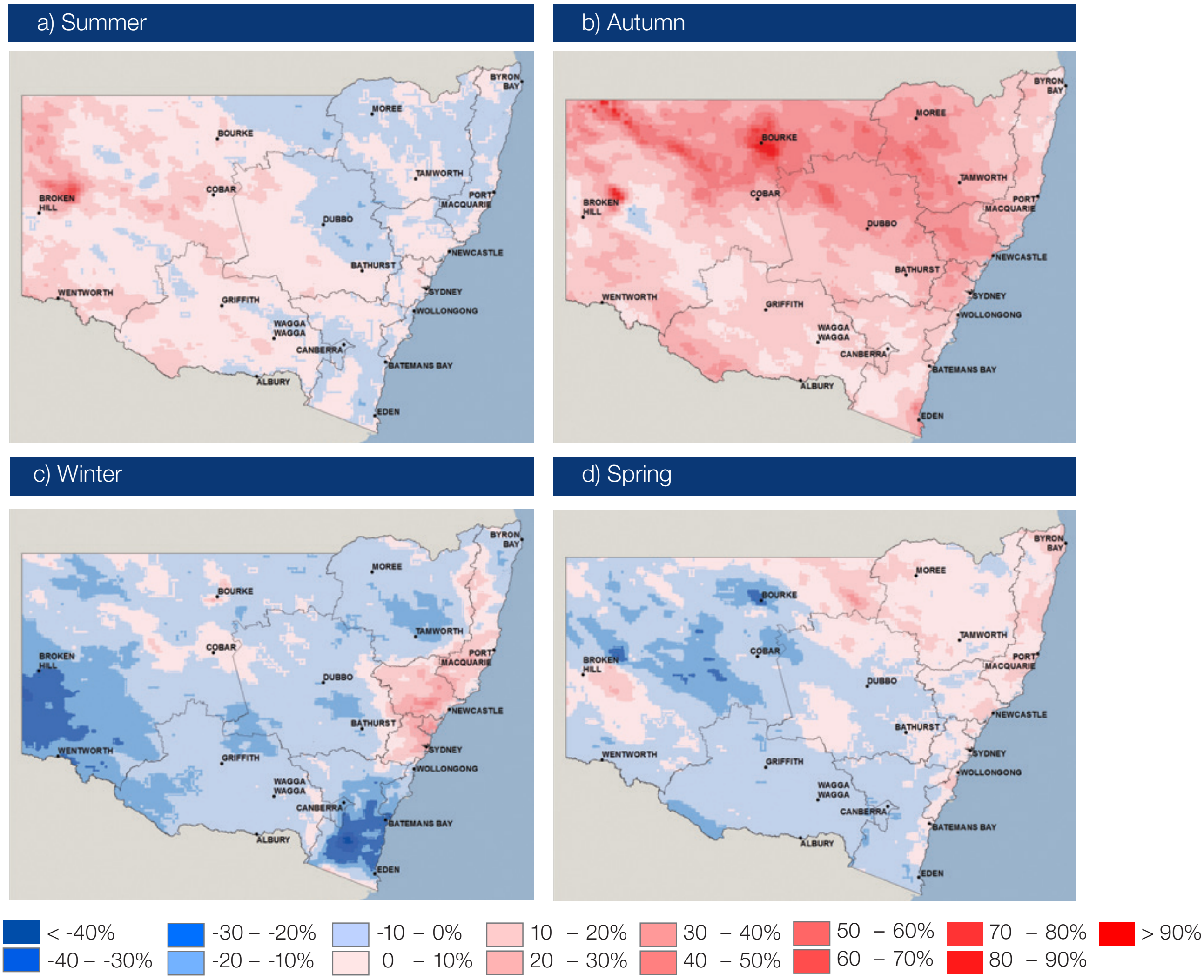


Figure 6: Seasonal changes (%) in rainfall erosivity in the near future (2020–2039) compared with the present (1990–2009)

Far future

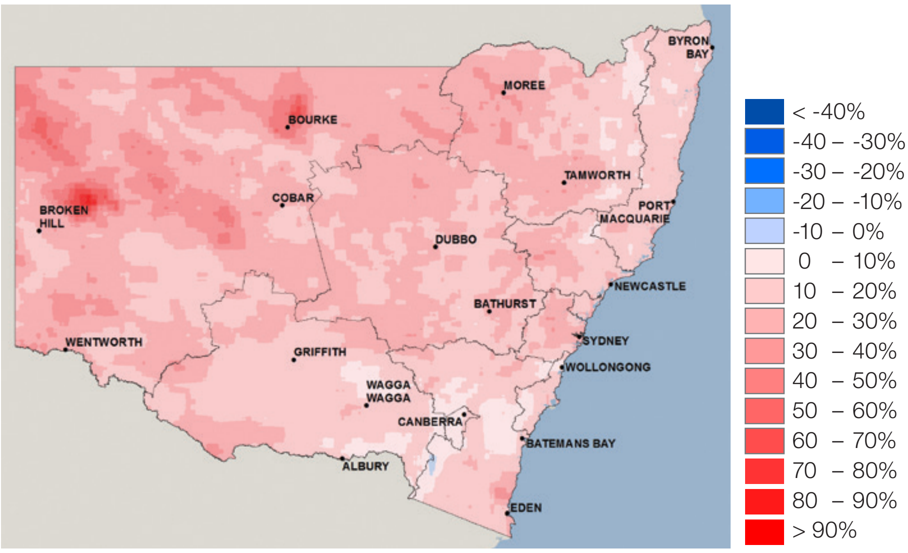


Figure 7: The percent change (%) in rainfall erosivity in the far future (2060–2079) compared with the present (1990–2009)

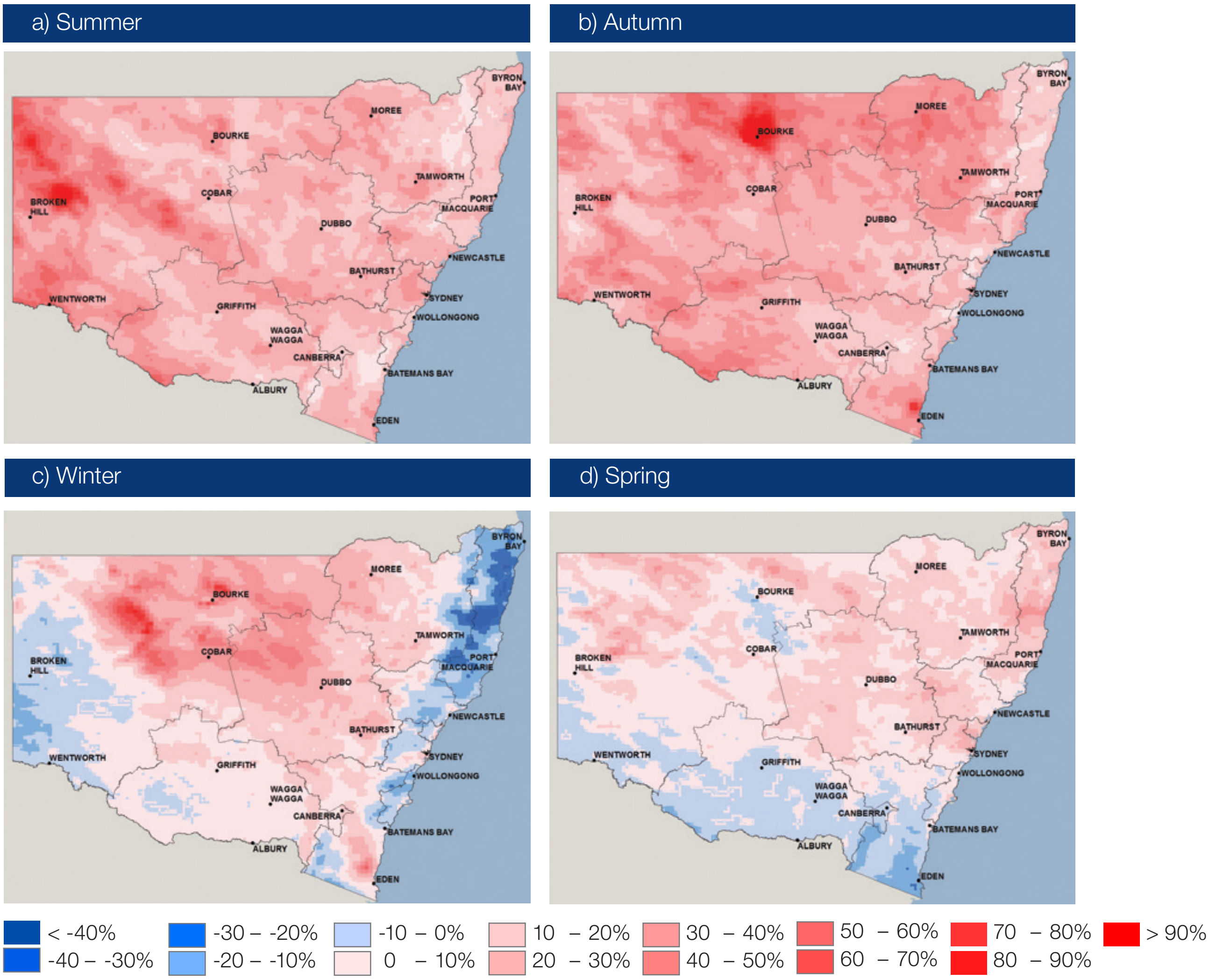


Figure 8: Seasonal changes (%) in rainfall erosivity in the far future (2060–2079) compared with the present (1990–2009)

Hillslope erosion

Current distribution

In NSW the east of the state (Great Dividing Range, North Coast and Illawarra regions) can currently have significant hillslope erosion. Figure 9 shows the current erosion risk across NSW. This is primarily due to the presence of more erosive rainfall (storm events) and steep terrains in these regions. Risk is also increased in the summer months when groundcover is low (Yang 2015).

Figure 10 shows the projected hillslope erosion risk if groundcover has been removed, which increases the erosion risk across the east of the State. The removal of all groundcover can occur after extreme events such as a severe bushfire. In these areas post-fire erosion is becoming an emerging environmental threat due to its potential adverse effects on soil and water quality. For example, a storm event in February 2013, which lasted approximately 45 minutes, caused considerable flooding and hillslope erosion in the severely burnt Warrumbungle National Park in January 2013, with the consequence of long-term landscape change in the park.

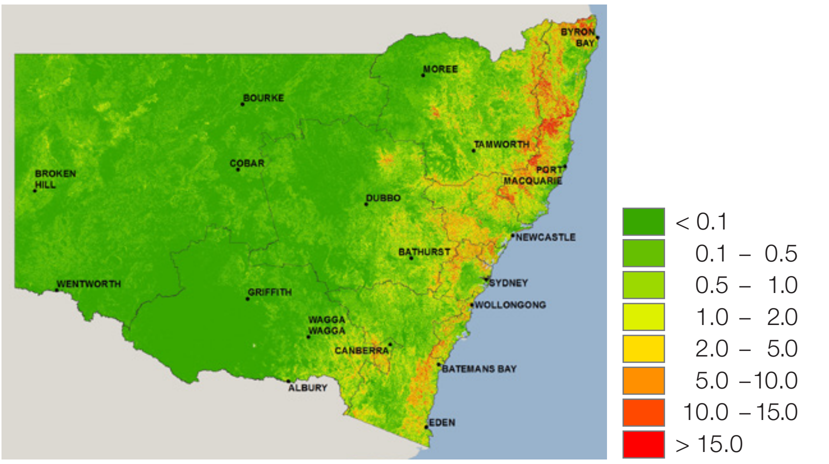


Figure 9: Baseline (1990–2009) mean annual hillslope erosion (t/ha/yr) with current groundcover conditions

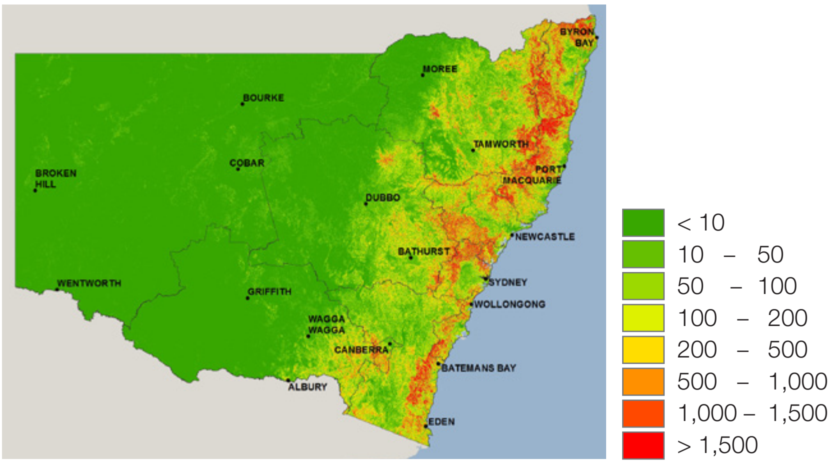


Figure 10: Baseline (1990–2009) mean annual hillslope erosion (t/ha/yr) without groundcover protection

Future impacts on hillslope erosion

Increasing erosivity leads to increases in actual soil erosion. This is particularly important in areas with high current erosion risk and also areas with significant values, for example, agricultural lands or nature conservation areas.

Table 1 details the changes in actual soil erosion caused from projected erosivity in the state planning regions in NSW. Areas such as the Far West and Central West and Orana are projecting large changes in erosivity (Figure 8 summer and autumn maps), but will experience very little actual erosion impacts (e.g. a maximum increase of 2.6 t/ha/yr by 2070), due to the flat plain terrain.

In contrast, areas which already experience high erosion rates are projected to see increases in erosion in both the near and far futures. For example, the Hunter region is projected to see a 20% increase in erosivity, which means the region could experience erosion events up to 195 t/ha/yr.

Figures 11 and 12 highlight the importance of groundcover maintenance in NSW. Figure 11 displays the projected hillslope erosion averaged across the state planning regions for baseline, near and far futures when current groundcover has been maintained. Figure 12 shows the increase in average erosion for the same regions and periods if the groundcover is removed. For example, along the Central Coast there is average erosion risk of approximately 5 t/ha/yr. However, if the groundcover is removed that risk increases to 750 t/ha/yr.

State planning region	Baseline (1990–2009) t/ha/yr		Near future (2020–2039) t/ha/yr		Far future (2060–2079) t/ha/yr		Near future change	Far future change
	Mean	Max	Mean	Max	Mean	Max	(%)	(%)
Far West	0.1	2.0	0.1	2.2	0.1	2.6	10.9	29.1
Murray Murrumbidgee	0.2	6.4	0.2	6.4	0.2	7.4	1.4	13.6
South East and Tablelands	1.1	9.1	1.1	9.5	1.2	10.9	1.0	14.5
Illawarra	2.2	14.6	2.3	15.3	2.5	15.8	3.6	11.8
Central West and Orana	0.5	13.0	0.5	13.8	0.6	15.3	4.6	20.0
New England and North West	0.9	24.0	0.9	24.2	1.1	27.9	4.3	17.4
North Coast	4.0	56.6	4.2	58.0	4.6	65.3	4.9	14.7
Hunter	3.7	157.6	4.2	179.7	4.5	194.9	11.4	20.3
Central Coast	4.4	13.5	5.0	15.4	5.3	16.0	14.4	20.0
Metropolitan Sydney	3.1	18.2	3.4	20.8	3.7	21.7	10.8	21.2
New South Wales	**2.0**	**31.5**	**2.2**	**34.5**	**2.4**	**37.8**	**6.7**	**18.2**

Table 1: Projected hillslope erosion (t/ha/yr) with the current groundcover conditions in state planning regions for baseline and future periods, and their changes

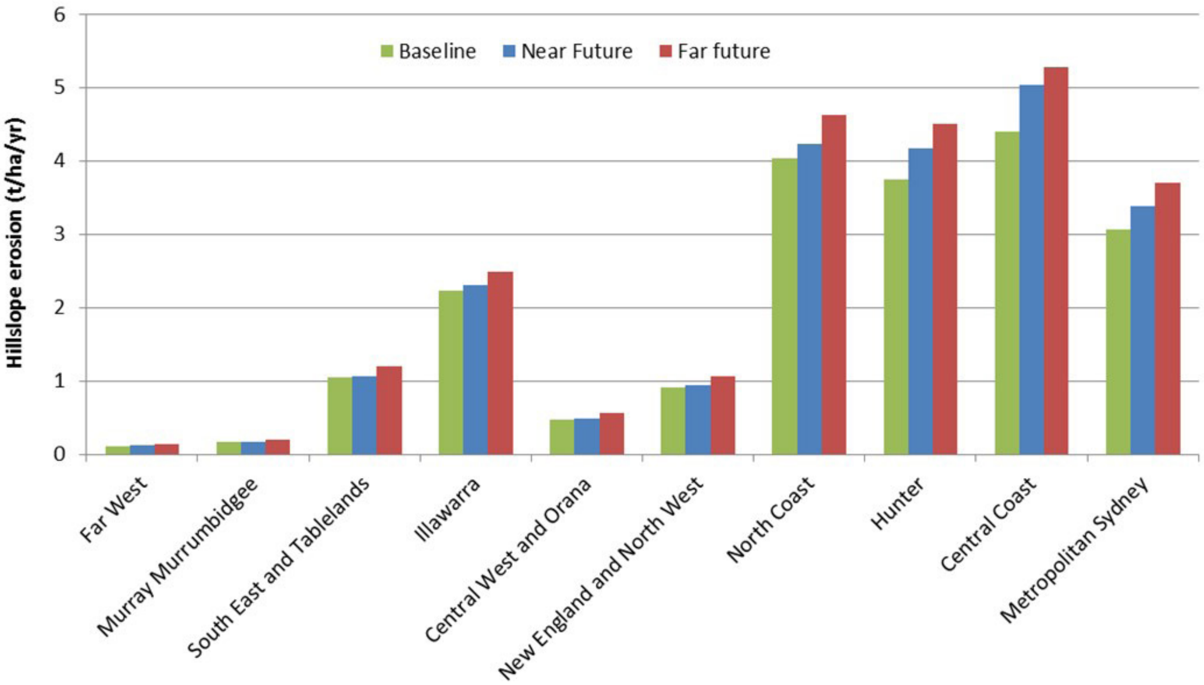


Figure 11: Projected mean annual hillslope erosion in state planning regions (with groundcover protection) in baseline (1990–2009), the near future (2020–39) and far future (2060–79)

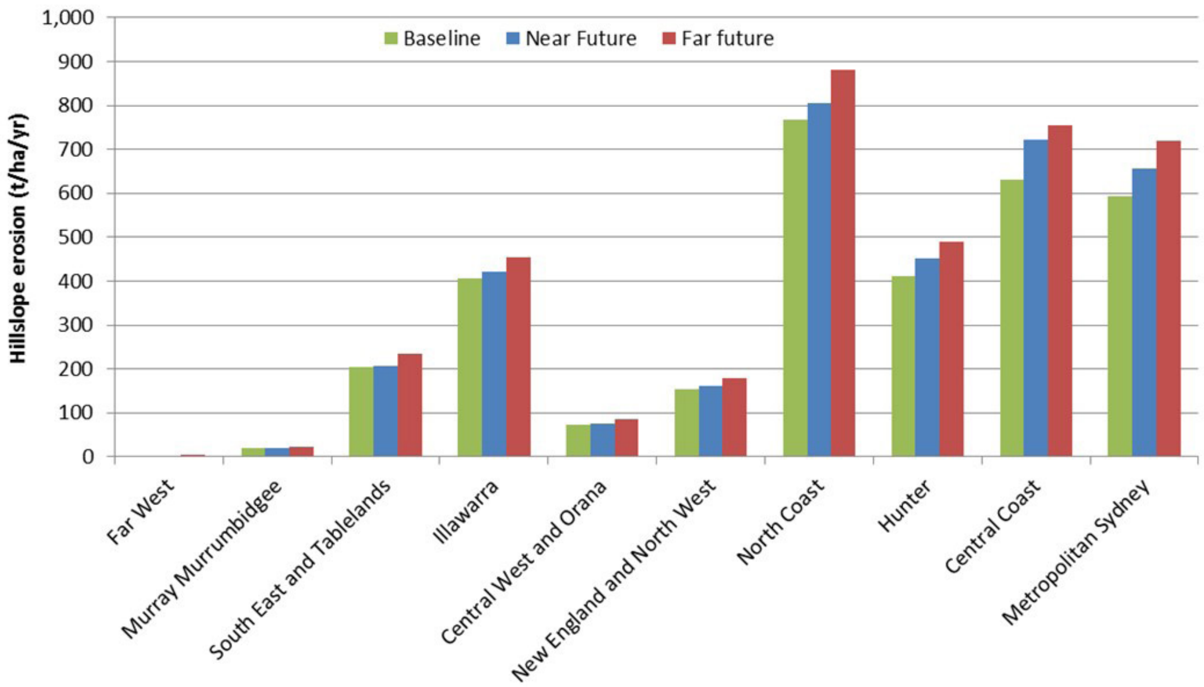


Figure 12: Projected mean annual hillslope erosion in state planning regions (without groundcover protection) in baseline (1990–2009), the near future (2020–39) and far future (2060–79). Note the scale difference compared to Figure 11.

Implications: Land-use management

Erosion also has implications for different land-uses. Figure 13 shows the current primary land-uses in NSW.

For the following land-use classes:

1. Conservation and natural environments
2. Production from relatively natural environments
3. Production from dryland agriculture and plantations
4. Production from irrigated agriculture and plantations
5. Intensive uses
6. Water

Figure 14 shows the projected erosion risk (the highest erosion when the groundcover is removed) to each land-use type.

The land-use type ‘Conservation and natural environments (Class 1) covers about 15% of NSW based on Australian Land-use and Management Classification Version 7 (ABARES 2010). Some areas in this class have the highest erosion risk, such as national parks which are normally in steep terrains with a higher frequency of bushfires (Figure 14). However, the actual erosion in these areas can be reduced considerably if groundcover is maintained (Yang 2014).

The ‘Intensive uses’ category (Class 5) are projected to have the second highest erosion risk due to the combined effects of groundcover (bare soil), terrain and rainfall erosivity. This category also includes urban areas and mining; the actual erosion risk is expected to far less than projected due to the large paved areas in the urban landscape.

The risk of hillslope erosion on NSW agricultural and plantation lands (Classes 3 and 4) is expected to only increase slightly, largely due to the topography of the land-uses, which is normally flatter terrain.

This detailed information could help decision-makers to better target and design the best management practices for a given land-use type or region.

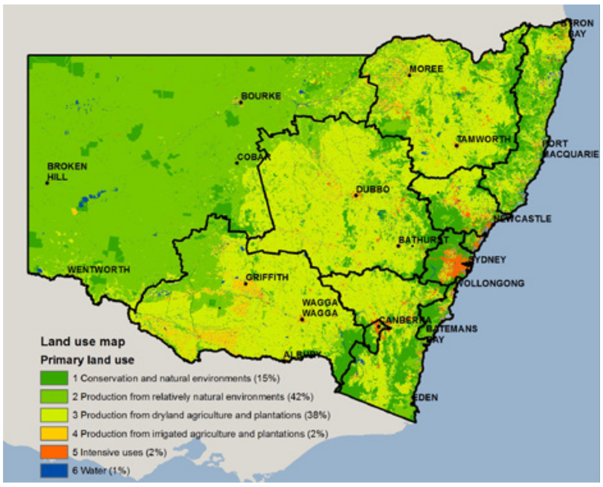


Figure 13: Primary land-uses in NSW and their class codes. (ABARES 2010)

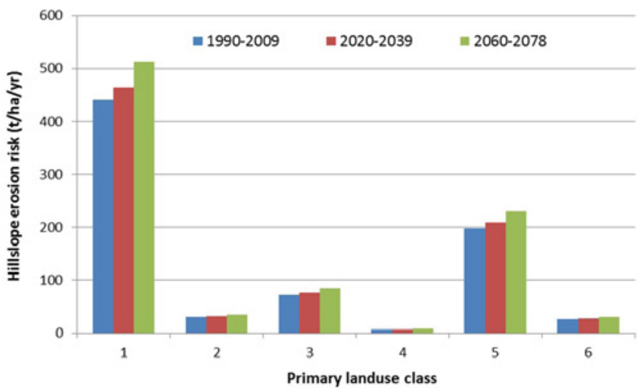


Figure 14: Projected erosion risk for different land-uses in NSW without groundcover.

Appendix 1 Guide to reading the maps and graphs

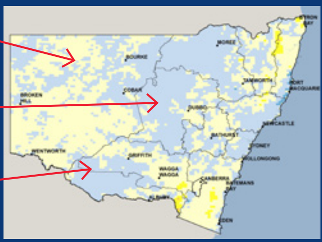
This document contains maps and bar graphs of the climate change projections, which are used to present the twelve model outputs as a central estimate calculated by averaging the results from the twelve models. The bar graphs show future projections averaged across the entire region and are not representative 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.



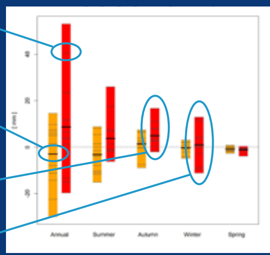
How to read the bar graphs

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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