North Western Plateau

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12 North Western Plateau

12.1 Introduction

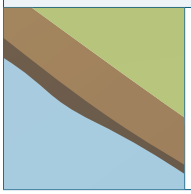
This chapter examines water resources in the North Western Plateau region in 2011–12 and over recent decades. It starts with summary information on the status of water flows, stores and use. This is followed by descriptive information for the region including the physiographic characteristics, soil types, population, land use and climate.

Spatial and temporal patterns in landscape water flows are presented as well as an examination of the surface and groundwater resources to finish the chapter. The data sources and methods used in developing the diagrams and maps are listed in the Technical Supplement.

12.2 Key information

Table 12.1 gives an overview of the key components of the data and information in this chapter.

Table 12.1 Key information on landscape water flows, floods and groundwater quality in the North Western Plateau region

Landscape water flows			
	Region average	Difference from 1911–2012 long-term annual mean	Decile ranking with respect to the 1911–2012 record
Rainfall	319 mm	+65%	10th—very much above average
Evapo-transpiration	291 mm	+61%	10th—very much above average
Landscape water yield	26 mm	+136%	10th—very much above average
Streamflow (at selected gauges)			
	Flooding:	Major flooding in the De Grey River basin	
Groundwater (in selected aquifers)			
	Salinity:	Scattered areas of saline groundwater (≥3000 mg/L) mainly surrounding (dry) riverbeds and lakes	

12.3 Description of the region

The North Western Plateau region is located in northwest Australia and includes major parts of the Great Sandy and Gibson deserts. The region covers 716,000 km² of land area and only has some limited surface water resources present in the northern and eastern parts of the region (see Figure 12.1).

The coastline consists of tide-dominated plains and tidal creeks. Dry lakes are scattered across the region, but aeolian landforms including dunes and sand plains dominate the landscape. Subsections 12.3.1–12.3.4 provide more information on the physical characteristics of the region.

With a population of 13,100 people, the North Western Plateau is home to less than 0.1% of the nation's total population (Australian Bureau of Statistics [ABS] 2011b).

Figure 12.1 shows the only major town of the region, Marble Bar. Subsection 12.3.6 provides some additional information on the population and distribution across the region.

The area is important for mineral resources and there are several mining operations in the region.

Most of the region is in a relatively natural state and 77% is associated with nature conservation.

A further 22% of the region is used for grazing, particularly along the western and northern boundaries (Figure 12.1). Irrigated agriculture and urban areas account for less than 0.01% of the region's area.

The climate is arid and is affected by erratic monsoonal rainfall, particularly in the north. Subsections 12.3.7 and 12.3.8 provide more information on the rainfall patterns and deficits across the region.

All the rivers in the region are ephemeral and only flow after a heavy rainfall.

The hydrogeology is dominated by a large area of outcropping fractured basement rock in the west and east of the region. The associated groundwater systems typically offer limited low volume water resources. Other important hydrogeological groups are the Mesozoic sediments through the centre of the region and the surficial sediments in-filling paleovalleys. These groups are likely to offer more reliable groundwater resources. Given the irregular nature of surface flows, water is generally supplied by groundwater.

A more detailed description of the rivers and groundwater status in the region is given in subsection 12.5.

Gibson Desert, Western Australia | Airspeed (iStockphoto)

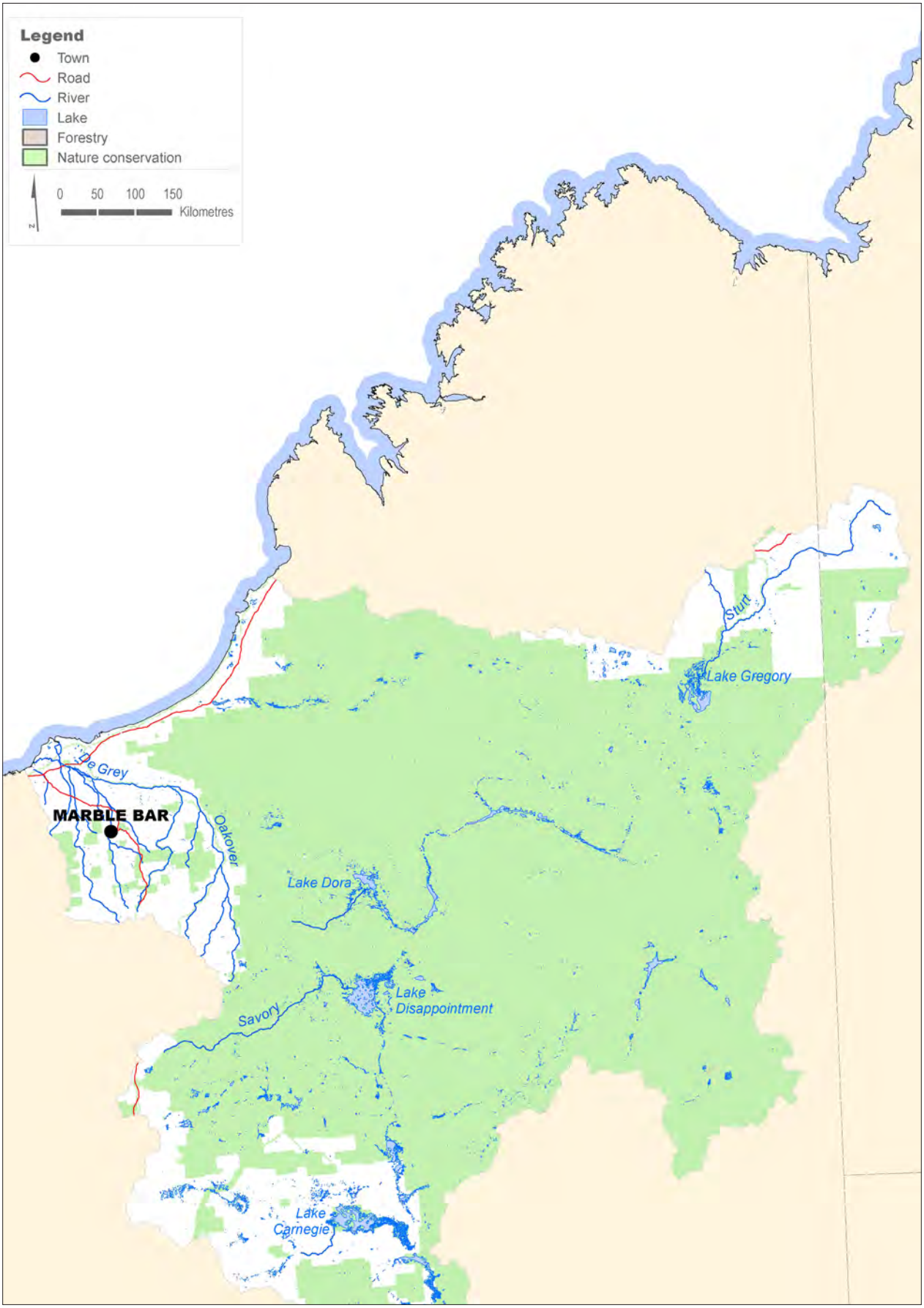


Figure 12.1 Major rivers and urban centres in the North Western Plateau region

12.3.1 Physiographic characteristics

The physiographic map in Figure 12.2 shows areas with similar landform evolutionary histories (Pain et al. 2011). These can be related back to similar geology and climatic impacts which define the extent of erosion processes, and have distinct physical characteristics that can influence hydrological processes.

The North Western Plateau region is dominated by the Sandland physiographic province which occupies 73% of its area. This province comprises mainly east-west longitudinal dunes with minor salt lakes. There are some sandy or stony ferruginous plains and low sandstone hills. The remaining five provinces occur along the region's southwest and northeast borders.

These provinces are:

- Pilbara (14%): largely dissected flat-topped hills of granitic, volcanic and metamorphic rocks interspersed by stony plains on granite;
- Barkly–Tanami Plains (7%): mainly sand plains with scattered low ranges and tablelands with occasional granite and sedimentary hills;
- Yilgarn Plateau (3.5%): sand, gravel and hardpan-wash plains with salt lakes, broken by ridges of metamorphic rocks and granite and mesas;
- Central Australian Ranges (2%): dunefields and sandplains with sandstone, granitic and volcanic ranges, salt lakes and calcrete plains; and
- Kimberley (0.5%): scattered tablelands, ranges of sedimentary rocks and plains with east-west longitudinal dunes.

Figure 12.2 Physiographic provinces of the North Western Plateau region

12.3.2 Elevation

As presented in Figure 12.3, aeolian landforms, including dunes and sand plains, dominate the landscape of the North Western Plateau. The region has no significant mountain ranges within its border. Information was obtained from the Geoscience Australia website (www.ga.gov.au/topographic-mapping/digital-elevation-data.html).

The southwest of the region has some higher altitudes with plateaus exceeding 600 m in altitude.

The region has some of the largest paleodrainage systems in Australia. They currently incorporate a number of aligned lakes. The topography clearly depicts the valleys these rivers have formed in the past.

Apart from the De Grey River in the far west, the region has no surface water flow to the Indian Ocean. Under heavy rainfall, the many closed river basins fill up the lakes that have formed over time; however, rainfall is very unreliable and lakes are normally dry.

Figure 12.3 Ground surface elevations in the North Western Plateau region

12.3.3 Slopes

Areas with steep slopes provide higher runoff generating potential than flat areas which are more favourable for vertical infiltration. The North Western Plateau region has generally a flat topography, without any distinct slopes (Table 12.2 and Figure 12.4).

Table 12 2. Proportions of slope classes for the region

Slope class (%)	0–0.5	0.5–1	1–5	> 5
Proportion of region (%)	50.6	31.7	16.9	0.8

The slightly steeper slopes particularly around Marble Bar in the west provide some gradient for streamflow to be generated (Figure 12.4). These headland streams occasionally reach the De Grey River, which flows into the Indian Ocean. The slopes were derived from the elevation information used in the previous section.

The absence of slopes and reliable rainfall makes this region highly receptive for aeolian influences. Former hills have been levelled out by wind erosion and plains are vast and covered with sand dunes.

Apart from the northern part, the border of the region is not a natural topographic water divide. Many small and large internally draining river basins exist on both sides of the border of the inland region.

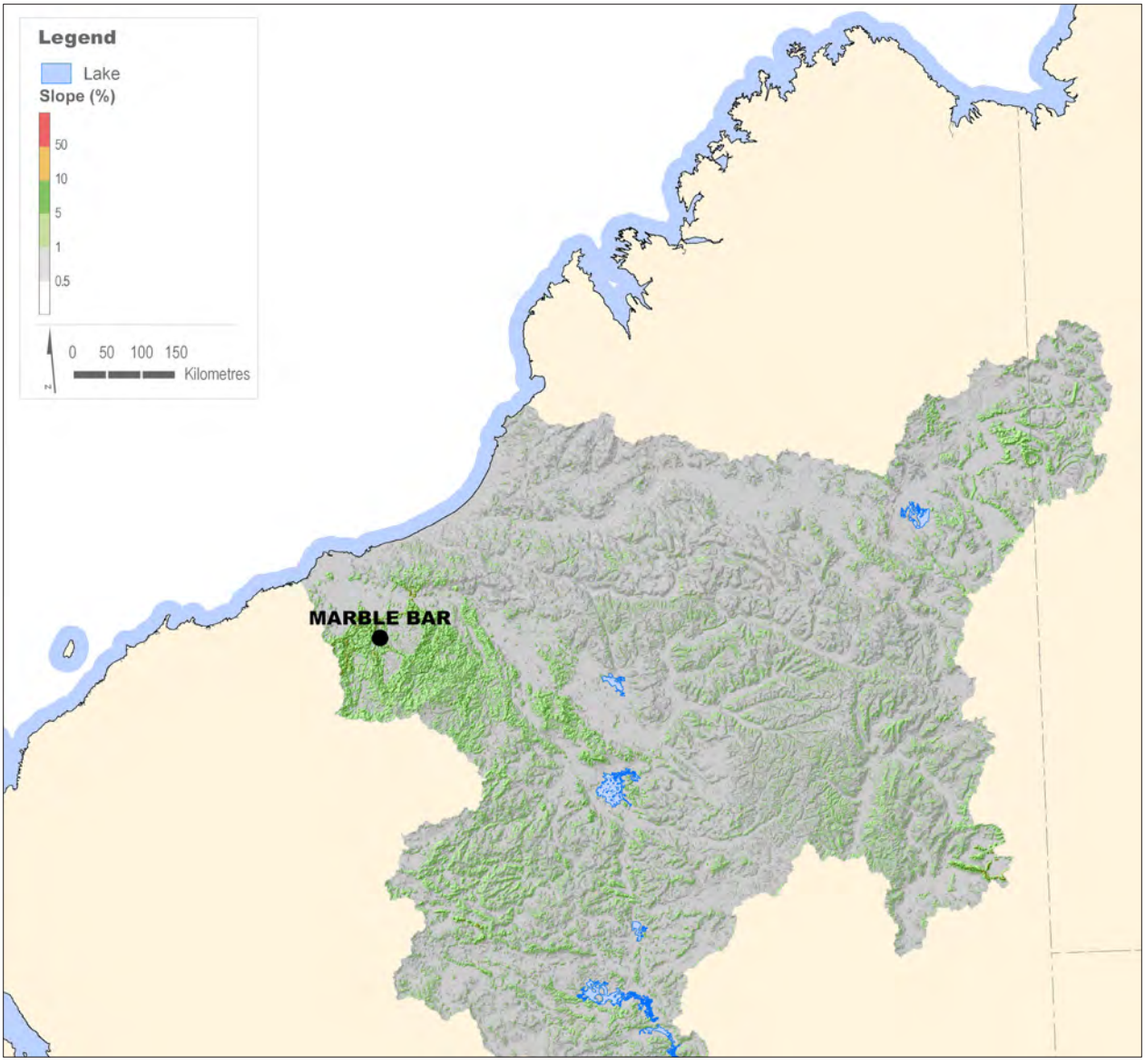


Figure 12.4 Surface slopes in the North Western Plateau region

12.3.4 Soil types

Soils play an important role in the hydrological cycle by distributing water that reaches the ground. Water can be transported to rivers and lakes via the soil surface as runoff or enter the soil and provide water for plant growth as well as contributing to groundwater recharge.

The nature of these hydrological pathways and the suitability of the soils for agricultural purposes are influenced by soil types and their characteristics. Soil type information was obtained from the Australian Soil Resource Information System website (www.asris.csiro.au).

About 90% of the North Western Plateau area is covered by three soil types, namely tenosols, rudosols and kandosols (Figure 12.5 and Figure 12.6).

Tenosols and rudosols are typically sandy, and show little change in texture and colour through the profile and are often shallow in depth. Tenosols and rudosols have low chemical fertility and have a low water-holding capacity, thus their agricultural potential is low. Both soil types are mostly present in areas used for nature conservation rather than agriculture.

Tenosols cover more than 50% of the total area of this region. They are dominant in all parts of the region, except for the northeast to southeast where rudosols are dominant.

Kandosols are structureless soils which are often very deep (up to three metres or more), but they do not have a strongly contrasting texture and they do not contain carbonate throughout their profile. They are low in chemical fertility and are well-drained, with only moderate water-holding capacity compared with other soil types; thus they only have low to moderate agricultural potential. They are mostly used for grazing in this region.

The other soil types that have minimal representation in the North Western Plateau region are sodosols, calcarosols, hydrosols, vertosols and chromosols (0.8–3%).

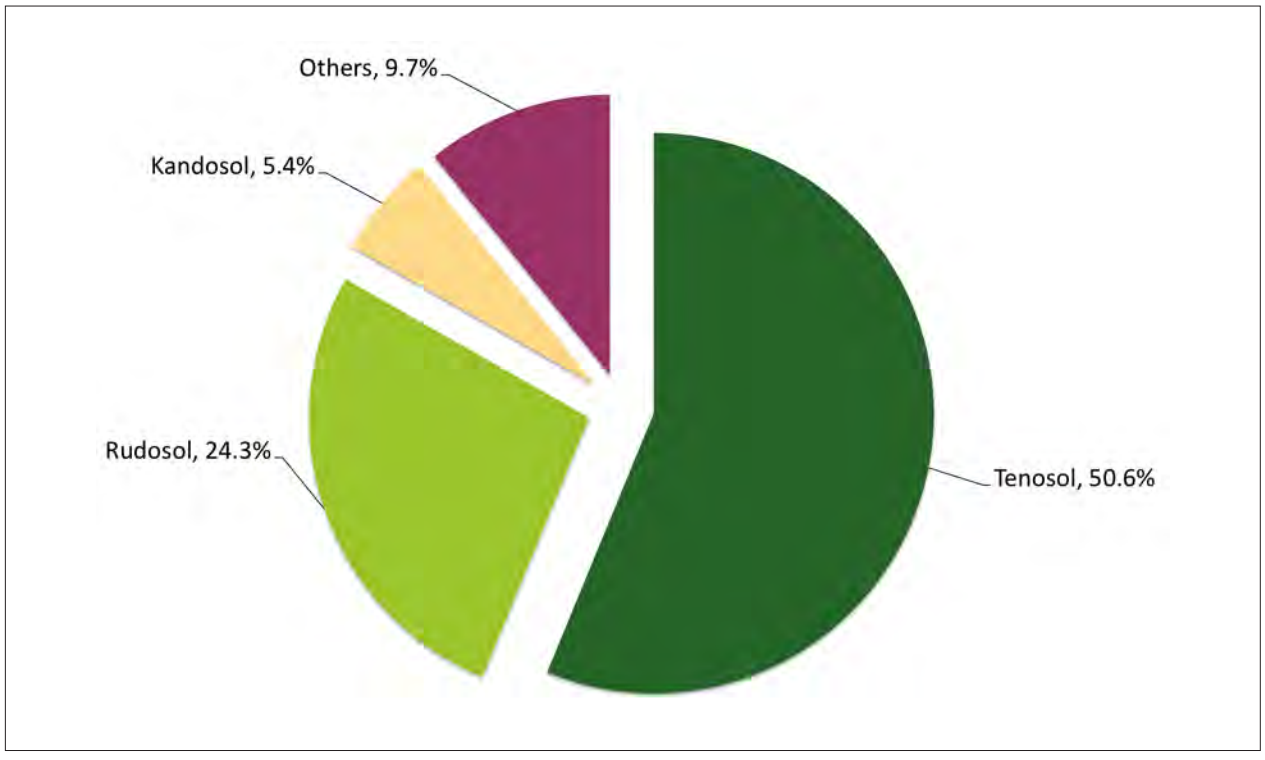


Figure 12.5 Soil types in the North Western Plateau region

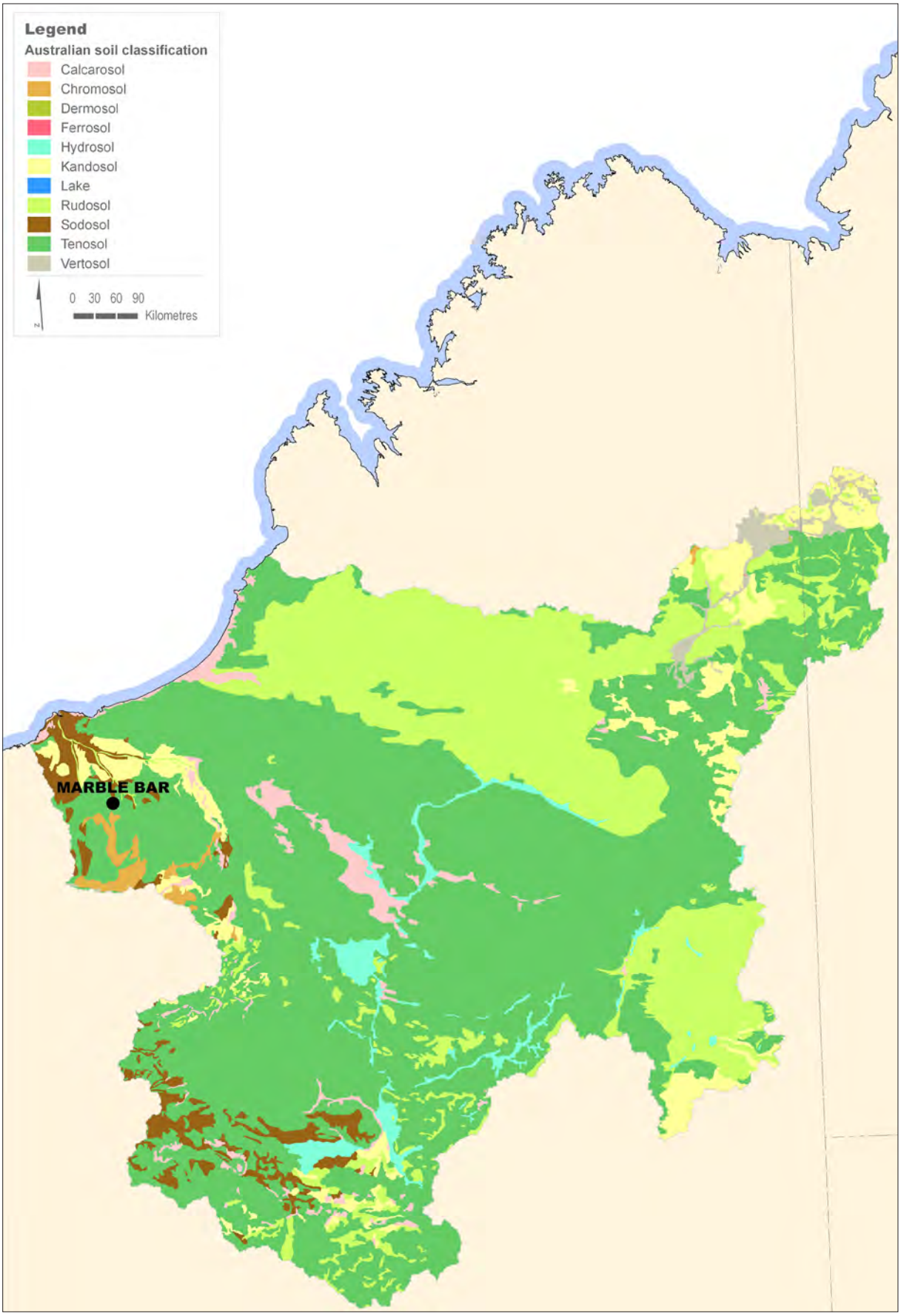


Figure 12.6 Soil type distribution in the North Western Plateau region

12.3.5 Land use

As presented in Figure 12.7 and Figure 12.8, most of the region is in a relatively natural state with 77% associated with nature conservation. A further 22% of the region is used for grazing along the western and northern boundaries. Irrigated agriculture and urban areas account for less than 0.01% of the area (data from data.daff.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml).

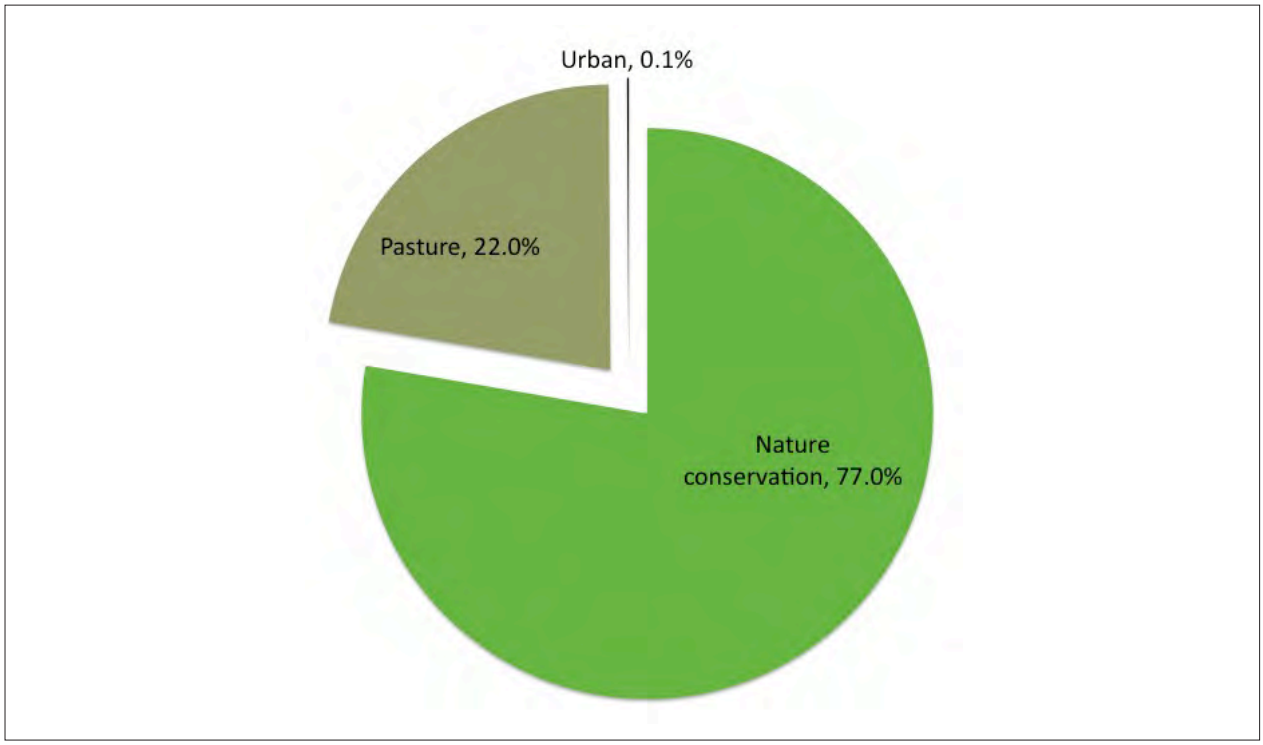


Figure 12.7 Land use in the North Western Plateau region

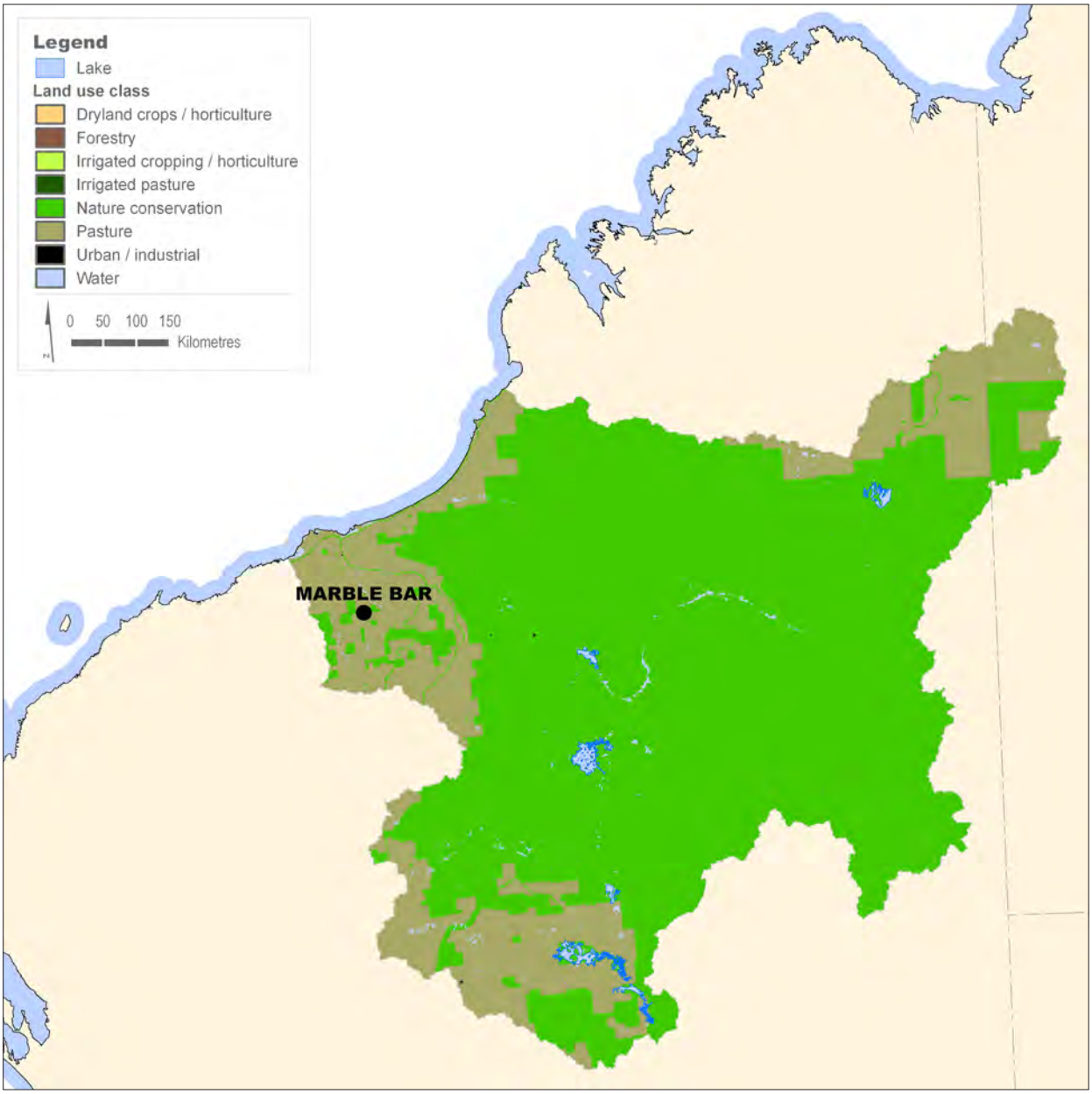


Figure 12.8 Land use distribution in the North Western Plateau region

12.3.6 Population distribution

With a population density in much of the region being zero, the North Western Plateau region is the least populated of the regions. The scarcity of the population is clearly illustrated in Figure 12.9 (ABS 2011b).

The largest of the permanent population centres is Marble Bar, located 200 km southwest of Port Hedland. Mining leases, remote Indigenous communities and a number of small settlements located adjacent to major roads in the region (including the Great Northern Highway and Marble Bar Road) account for the remaining population.

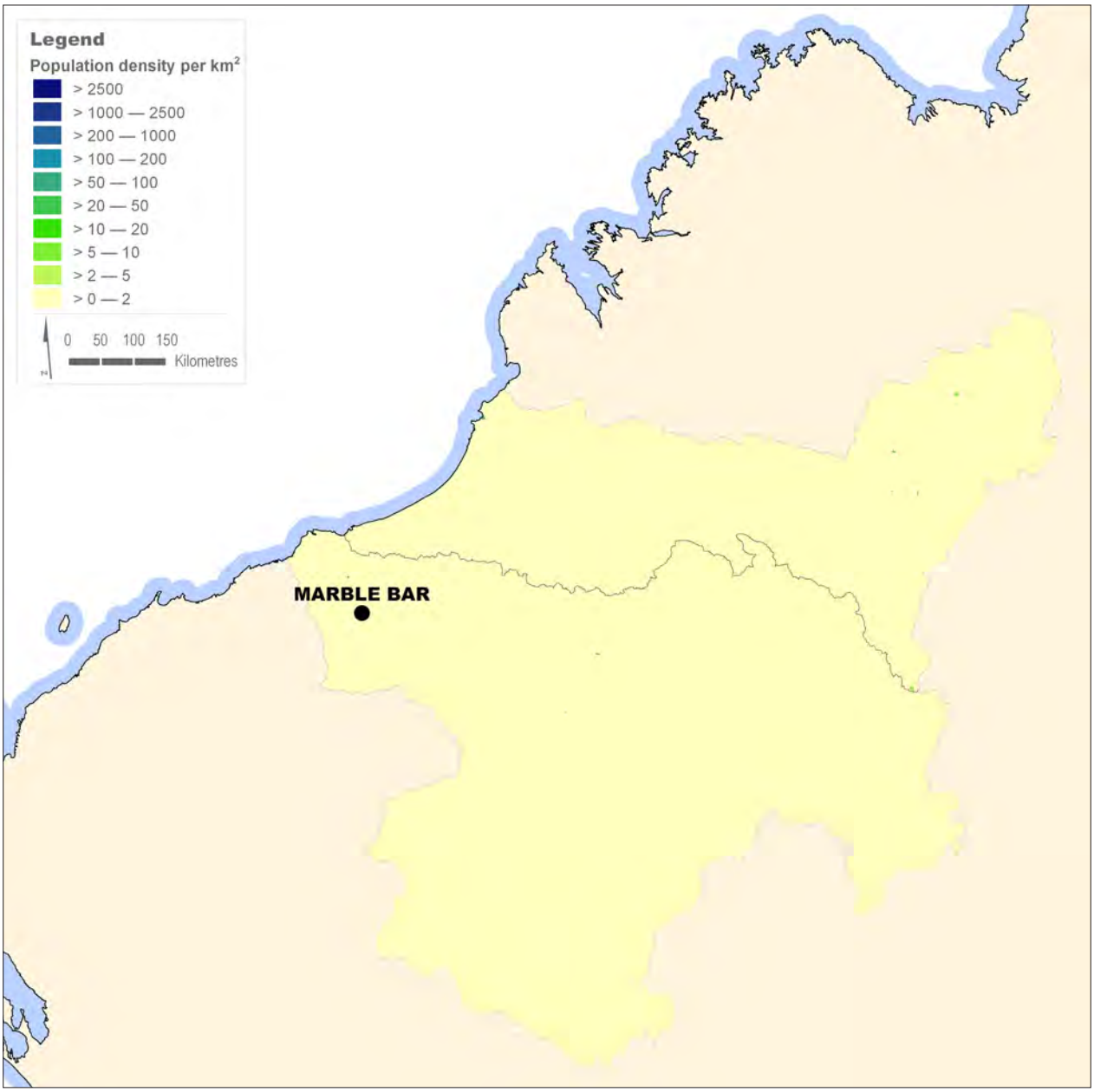


Figure 12.9 Population density and distribution in the North Western Plateau region

12.3.7 Rainfall zones

The region's climate is semi-arid to arid. The northern part is affected by occasional monsoonal rainfall in summer. Median rainfall does not exceed 650 mm per annum (Figure 12.10).

In the northern part of the region, rainfall is very irregular. Relatively low rainfall amounts can occur over the wet season, due to the limited extent of the monsoon and tropical depressions, and storms often bypass the region.

The arid south receives average annual rainfall totals generally not exceeding 300 mm. As with many arid zones, rainfall is very unreliable and highly variable between years.

For more information on this and other climate classifications, visit the Bureau of Meteorology's (the Bureau's) climate website (www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp).

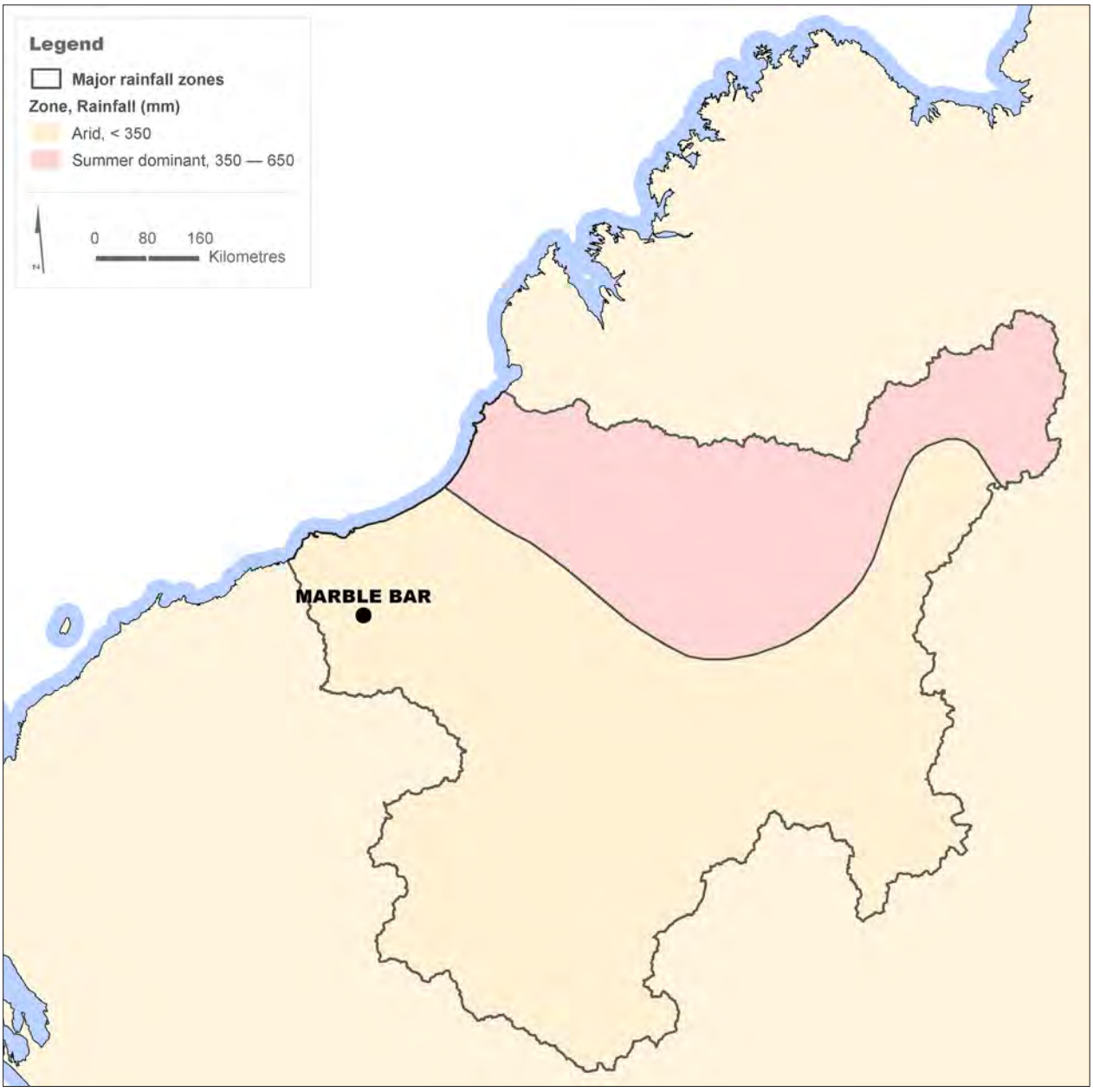


Figure 12.10 Rainfall zones in the North Western Plateau region

12.3.8 Rainfall deficit

The rainfall deficit indicator, that is, rainfall minus potential evapotranspiration, gives a general impression of which parts of the region are likely to experience moisture deficits over the period of a year. The North Western Plateau region has a uniform pattern of serious potential deficits (Figure 12.11).

Most of the region consists of desert land with some ephemeral streams and lakes. The moisture deficits in this area allow sand dunes and plains to dominate the landscape.

In the north, the unreliable supply of rainfall and the long dry season create a harsh environment. Marble Bar has the world's longest record (161 consecutive days) of above 37.8 °C. The majority of the region is declared as nature conservation land, containing some unique flora and fauna.

For more information on the rainfall and evapotranspiration data, see the Bureau's maps of average conditions (www.bom.gov.au/climate/averages/maps.shtml).

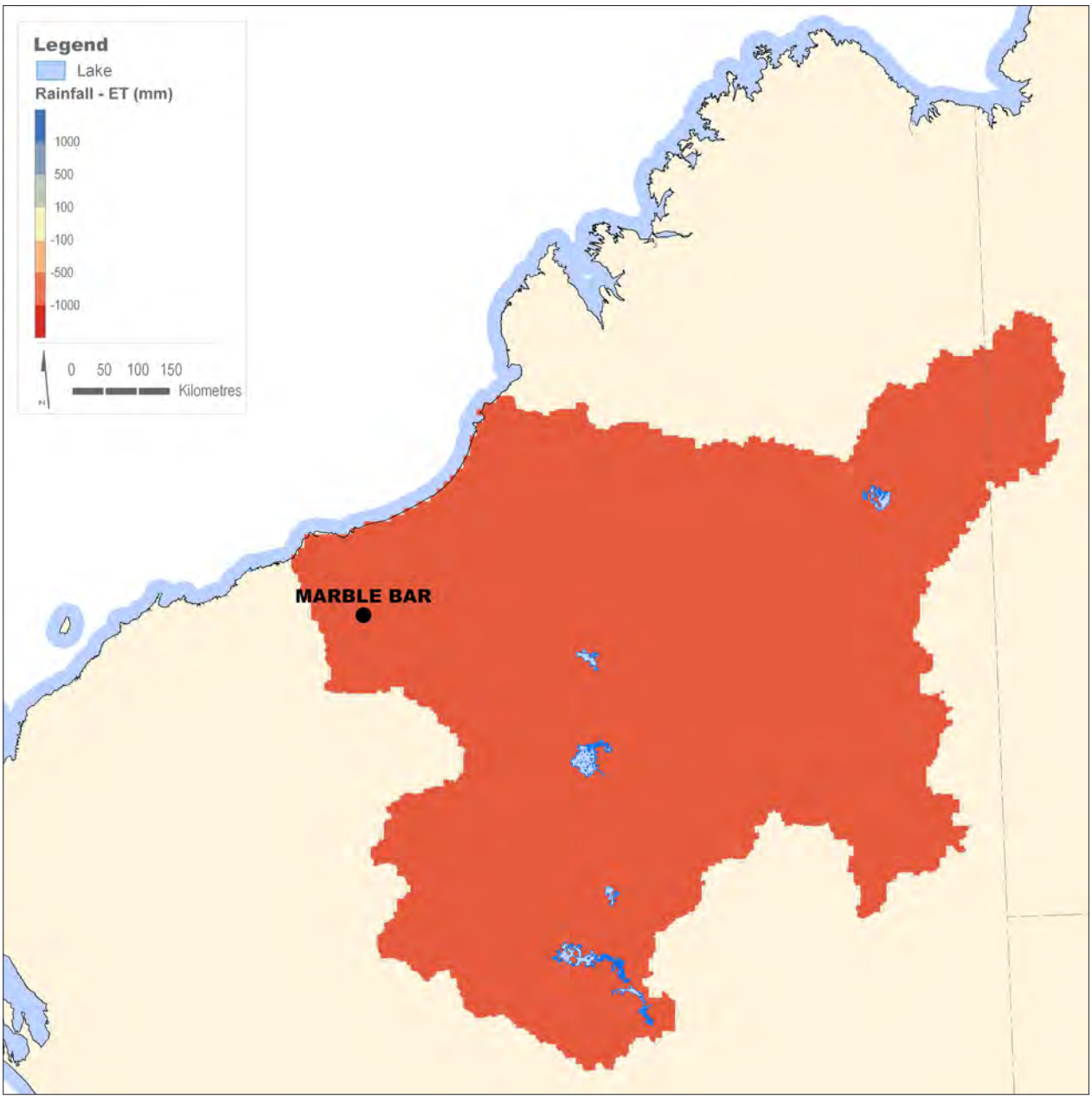


Figure 12.11 Rainfall deficit distribution in the North Western Plateau region

12.4 Landscape water flows

This section presents analyses of the spatial and temporal variation of landscape water flows (rainfall, evapotranspiration and landscape water yield) across the North Western Plateau region in 2011–12. National rainfall grids were generated using data from a network of persistent, high-quality rainfall stations managed by the Bureau. Evapotranspiration and landscape water yields were derived using the landscape water balance component of the Australian Water Resources Assessment System (Van Dijk 2010). These methods and associated output uncertainties are discussed in the Introduction and addressed in more detail in the Technical Supplement.

Figure 12.12 shows that the region has a highly seasonal rainfall pattern with a relatively wet summer and a dry winter period. Evapotranspiration in the dry winter period generally exceeds rainfall. After the wet period the soils normally contain an above average water volume that is available for evapotranspiration. The monthly landscape water yield history for the region shows a stable pattern of very low yield in the dry period. It only increases marginally during the summer period (November to April).

The 2011–12 year was a relatively wet year, particularly between October 2011 and March 2012, when rainfall was much higher than the historic median. In 2011, the region recorded the highest November rainfall on record (1911–2012). In fact, the period between October 2011 and January 2012 was the wettest on record for this four-month period. In March the passage of tropical cyclone *Lua* also caused heavy falls and flooding.

With wet conditions present at the start of the year and the excess of rainfall in November and January, evapotranspiration was particularly high throughout the year. Evapotranspiration was highest on record for the November month, and second-highest on record in the October–January period.

Landscape water yield for 2011–12 started to increase in January. March had the highest monthly landscape water yield for the year.

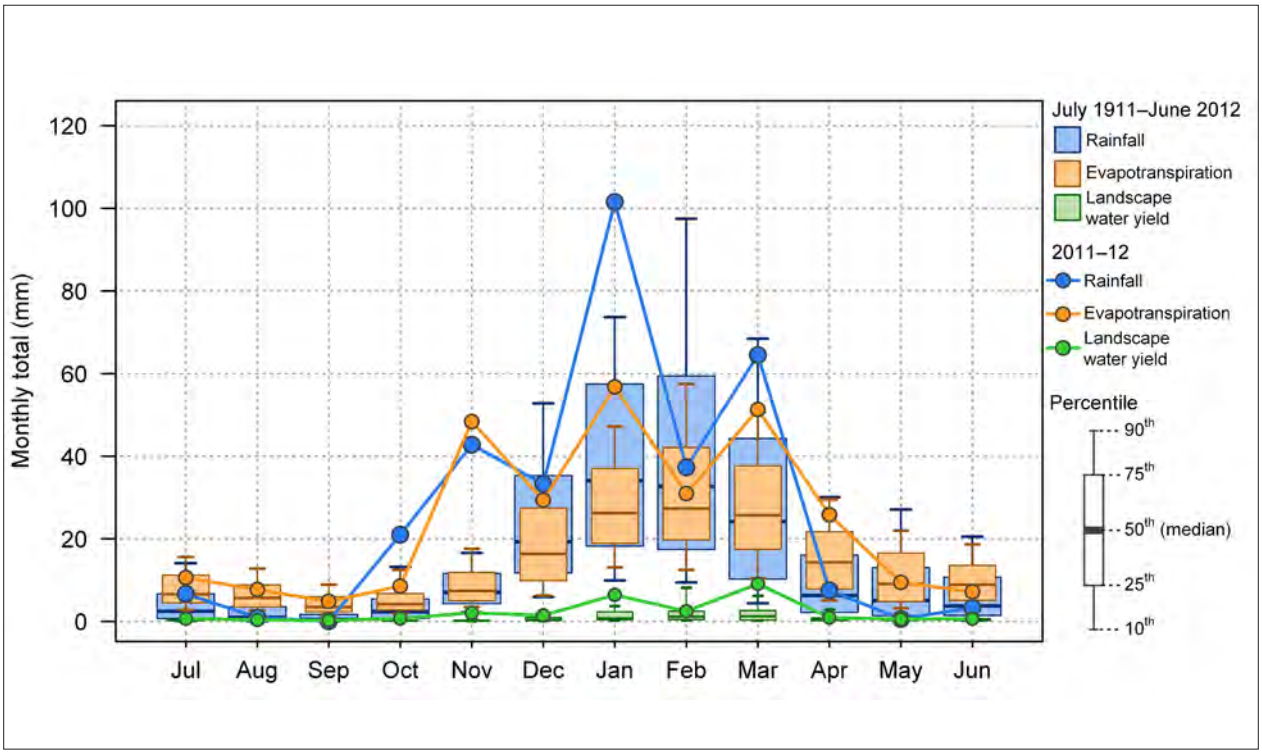


Figure 12.12 Landscape water flows in 2011–12 compared with the long-term record (July 1911–June 2012) for the North Western Plateau region

12.4.1 Rainfall

Rainfall for the North Western Plateau region for 2011–12 is estimated to be 319 mm. This is 65% above the region's long-term average (July 1911–June 2012) of 193 mm. Figure 12.13a shows a large proportion of uncertainty of rainfall data in the region. This is due to a low rain gauge density and explains the low rainfall in the centre of the region. For consistency reasons, however, this area included for calculating totals and statistics.

Rainfall in 2011–12 marginally exceeded 600 mm per year, generally in the areas that show very much above average rainfall in Figure 12.13b. For the remainder of the region with reasonable data reliability, rainfall deciles for 2011–12 indicate predominantly above average rainfall.

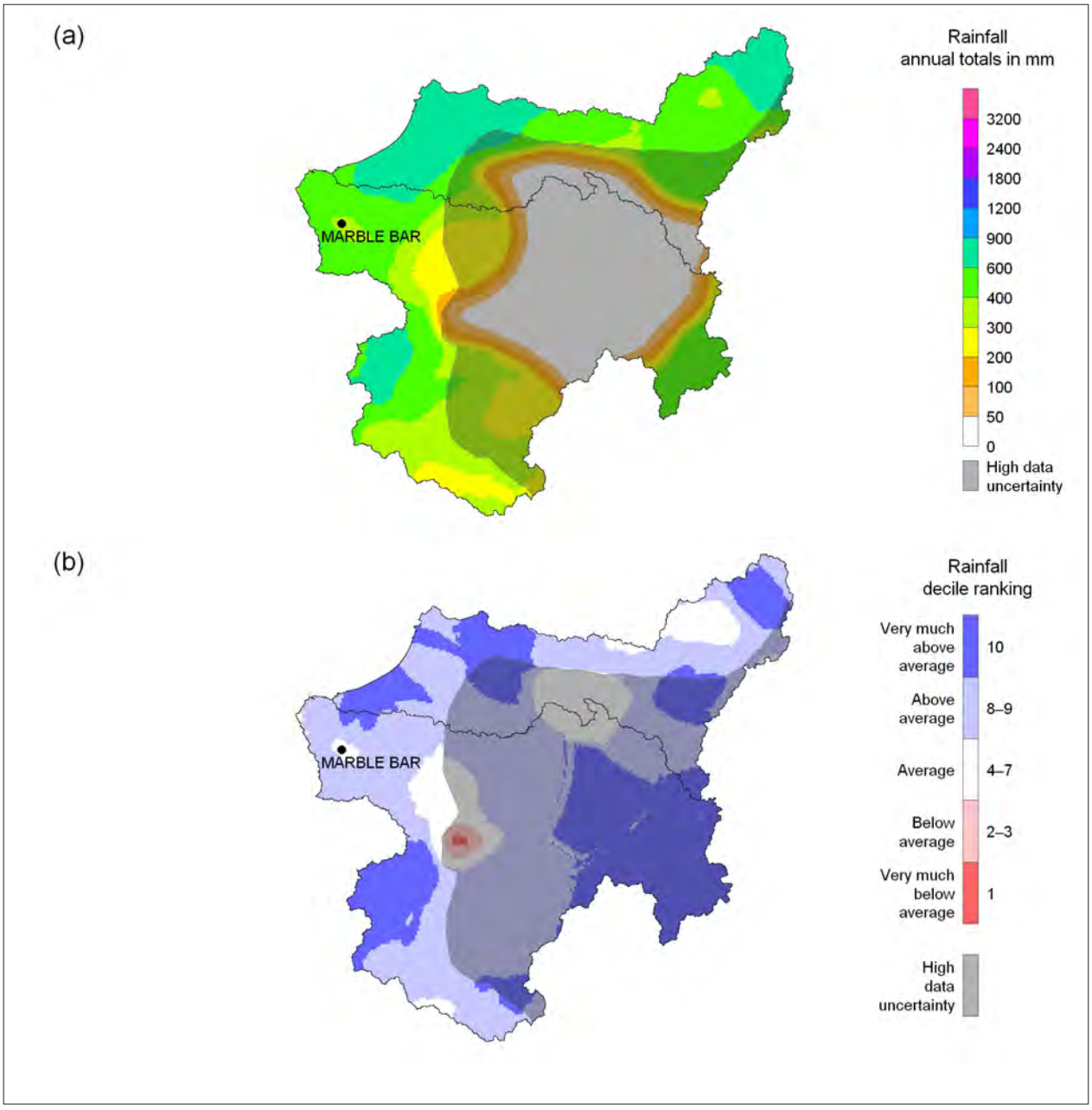


Figure 12.13 Spatial distribution of (a) annual rainfall in 2011–12, and (b) their decile rankings over the 1911–2012 period for the North Western Plateau region

Rainfall variability in the recent past

Figure 12.14a shows annual rainfall for the region from July 1980 onwards. Over this 32-year period the annual average was 264 mm, varying from 119 mm (1989–90) to 502 mm (1999–2000). Temporal variability and seasonal patterns (over the summer and winter periods) since 1980 are presented in Figure 12.14b.

The graphs indicate the dependency of annual rainfall on the amount of rainfall occurring in the summer period. Rainfall in the winter period is generally low and relatively stable between years whilst rainfall in the summer period is highly variable. Consequently annual rainfall is highly variable as well (Figure 12.14a). In fact, the North Western Plateau has the second highest coefficient of variation (standard deviation divided by the mean) for annual rainfall compared to other reporting regions of Australia, only behind its neighbour, the Pilbara–Gascoyne region.

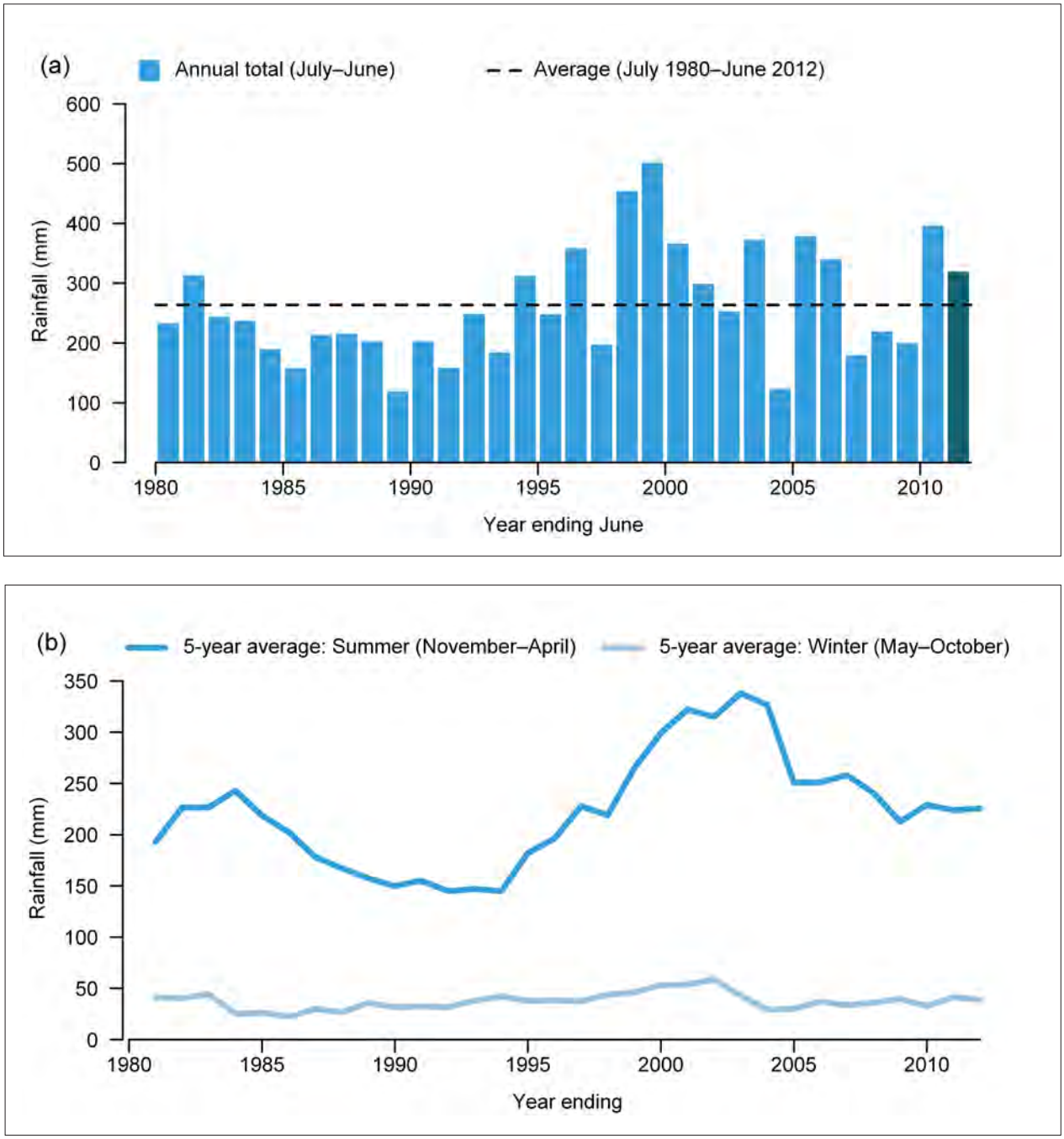


Figure 12.14 Time-series of (a) annual rainfall, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the North Western Plateau region

Recent trends in rainfall

Figure 12.15a presents the spatial distribution of the trends in annual rainfall for July 1980–June 2012. These are derived from linear regression analyses on the time-series of each model grid cell. The statistical significance of the trends is provided in Figure 12.15b.

Figure 12.15a shows that since 1980 an increase in rainfall has occurred in large parts of the region. The significance of the trends is particularly strong in the south of the region.

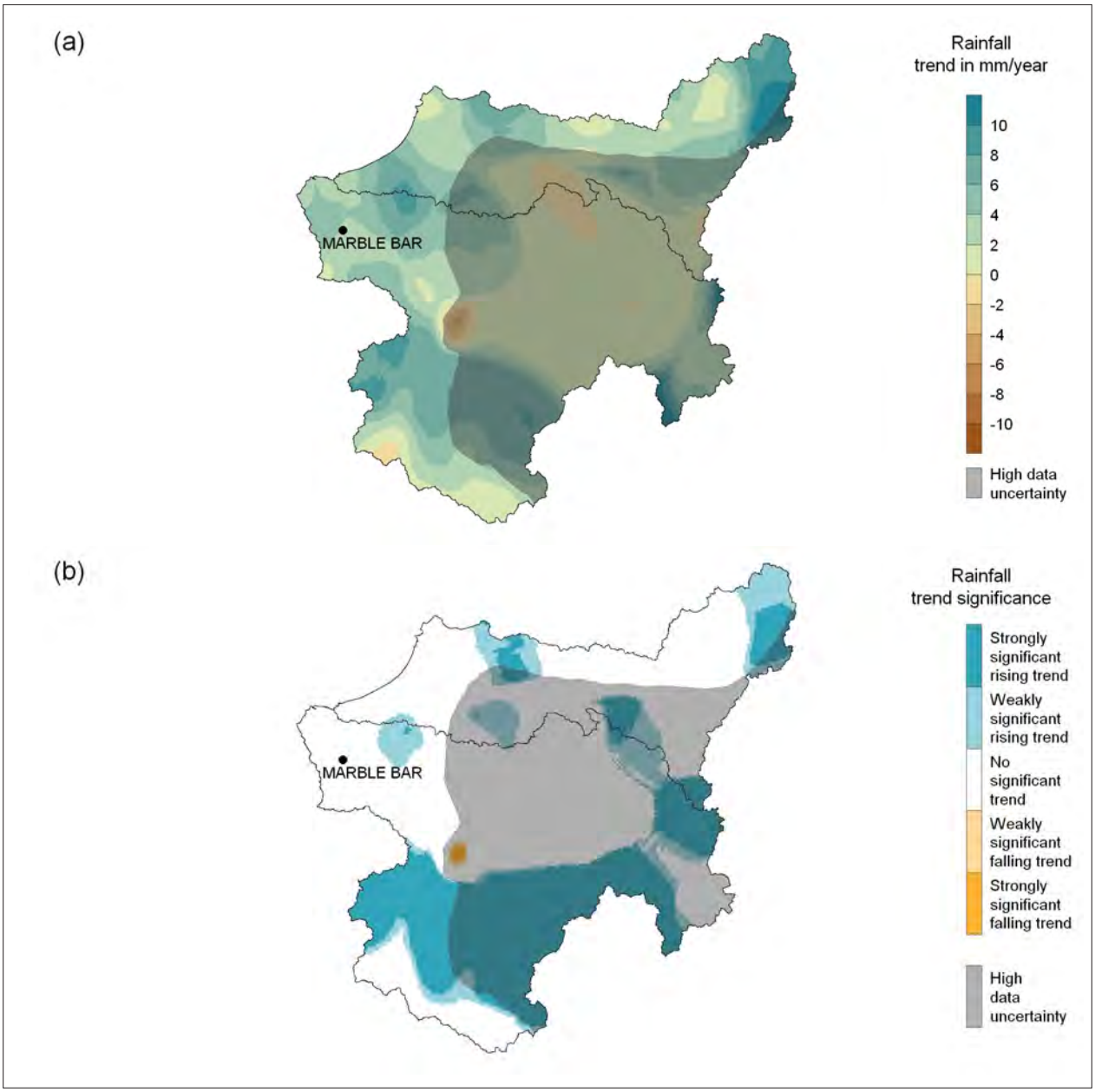


Figure 12.15 Spatial distribution of (a) trends in annual rainfall from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the North Western Plateau region

12.4.2 Evapotranspiration

Modelled annual evapotranspiration for the North Western Plateau region for 2011–12 is estimated to be 291 mm. This is 61% above the region's long-term (July 1911– June 2012) average of 181 mm. The spatial distribution and magnitude of annual of evapotranspiration in 2011–12 (Figure 12.16a) is similar to that of rainfall (Figure 12.13a).

Evapotranspiration deciles for 2011–12 indicate above average or very much above average totals across most of the region (Figure 12.16b). It also resembles the rainfall patterns of Figure 12.13b rather closely, which indicates that water availability, through rainfall, limits the amount of evapotranspiration occurring.

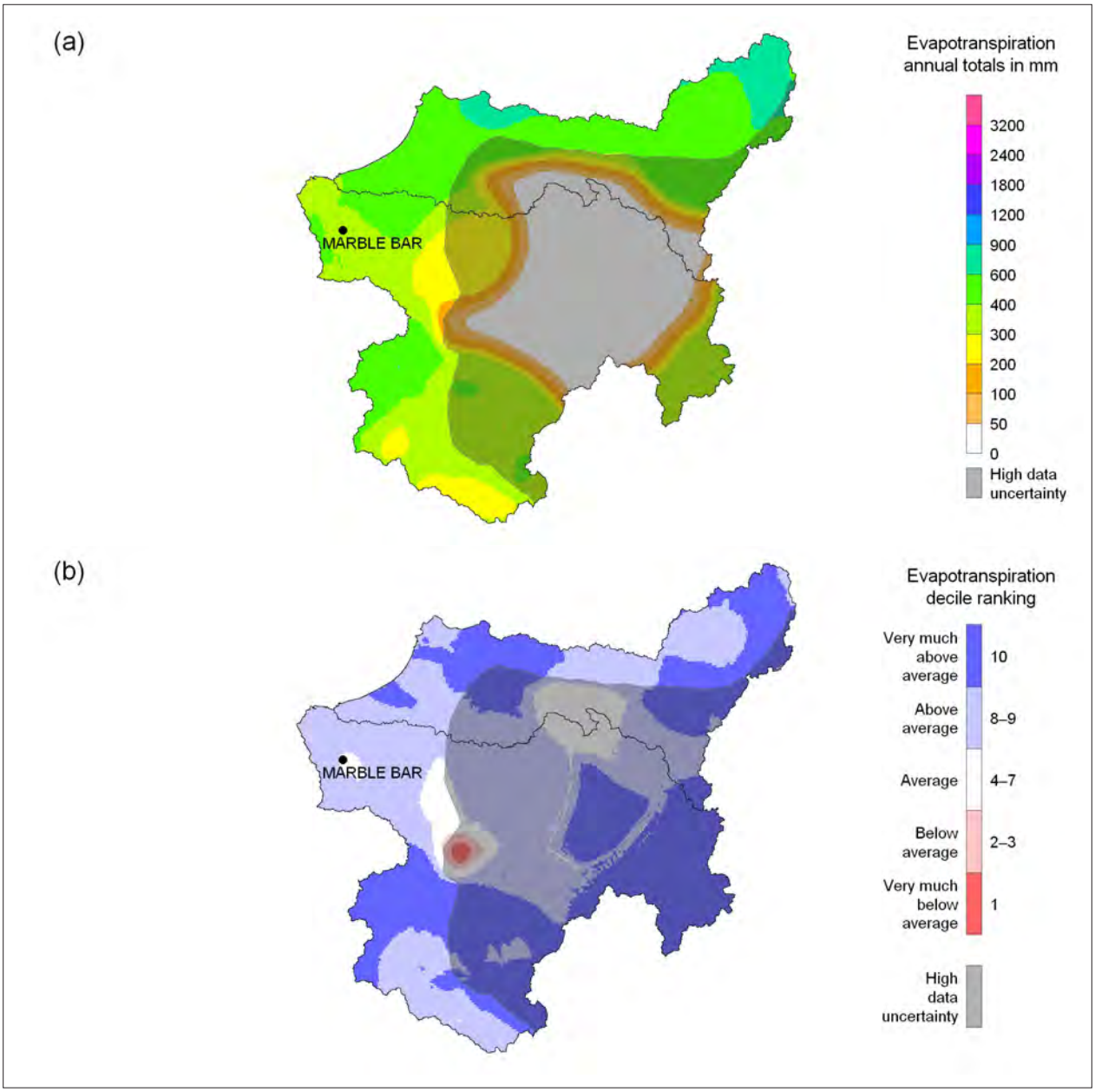


Figure 12.16 Spatial distribution of (a) modelled annual evapotranspiration in 2011–12, and (b) their decile rankings over the 1911–2012 period for the North Western Plateau region

Evapotranspiration variability in the recent past

Figure 12.17a shows annual evapotranspiration for the region from July 1980 onwards. Over this 32-year period the annual evapotranspiration average was 242 mm, varying from 140 mm (1985–86) to 411 mm (1999–2000). Temporal variability and seasonal patterns (over the summer and winter periods) since 1980 are presented in Figure 12.17b.

Summer periods show consistently higher evapotranspiration than the winter period. The higher temperatures and the higher rainfall amounts during these periods are the main contributing factors. Compared with seasonal rainfall (Figure 12.14b), evapotranspiration exceeds the input of rain during the winter period. This is due to the higher availability of soil moisture after the relatively wet summer period.

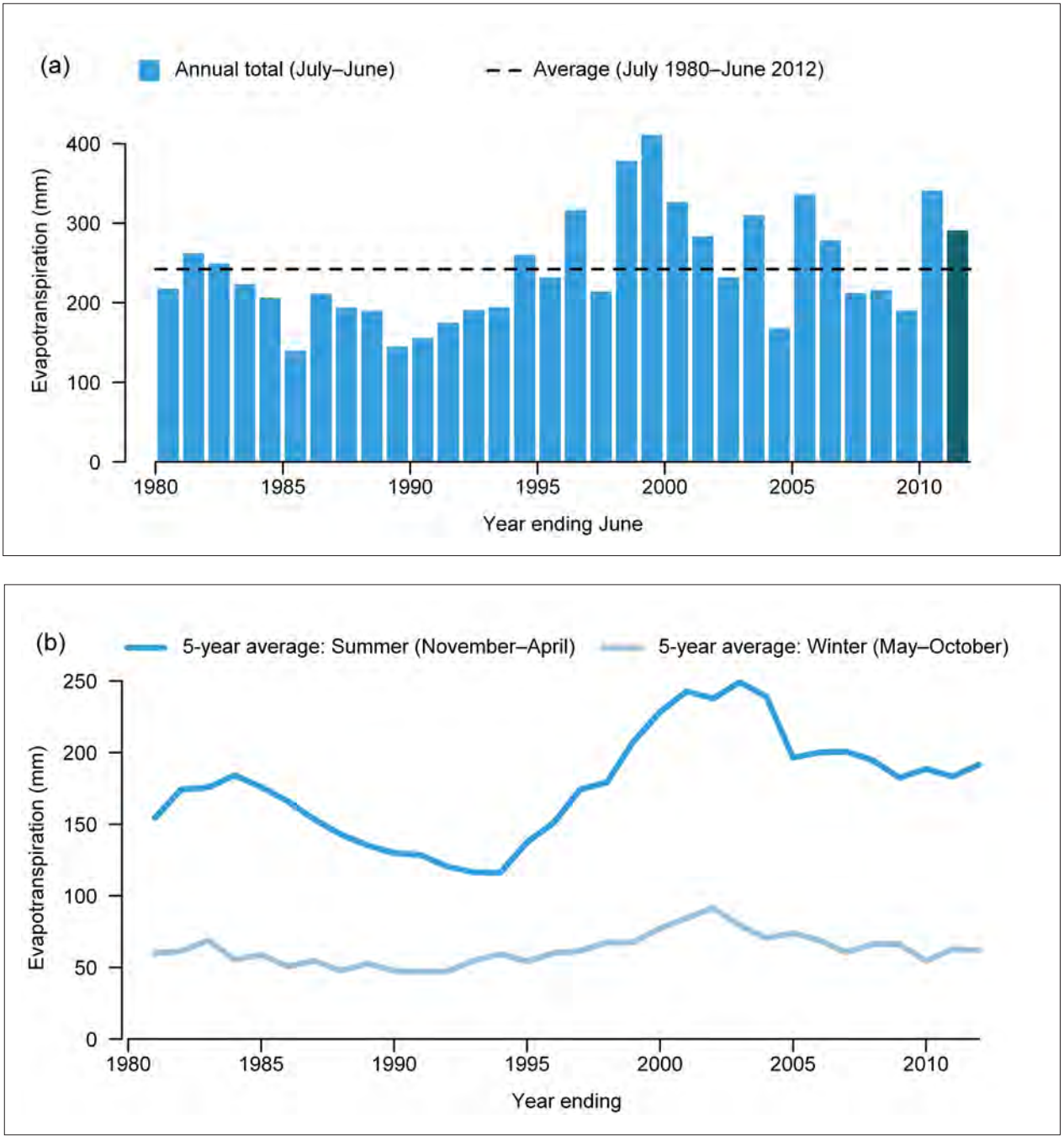


Figure 12.17 Time-series of (a) annual evapotranspiration, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the North Western Plateau region

Recent trends in evapotranspiration

Figure 12.18a presents the spatial distribution of the trends in modelled annual evapotranspiration for 1980–2012. These are derived from linear regression analyses on the time-series of each model grid cell. The statistical significance of the trends is provided in Figure 12.18b.

Figure 12.18a shows that since 1980, trends are mostly positive throughout the region. Similar areas of statistical significance (Figure 12.18b) are identified as compared to the rainfall trend significance in Figure 12.15b, though the areas of statistically significant evapotranspiration increase are somewhat larger.

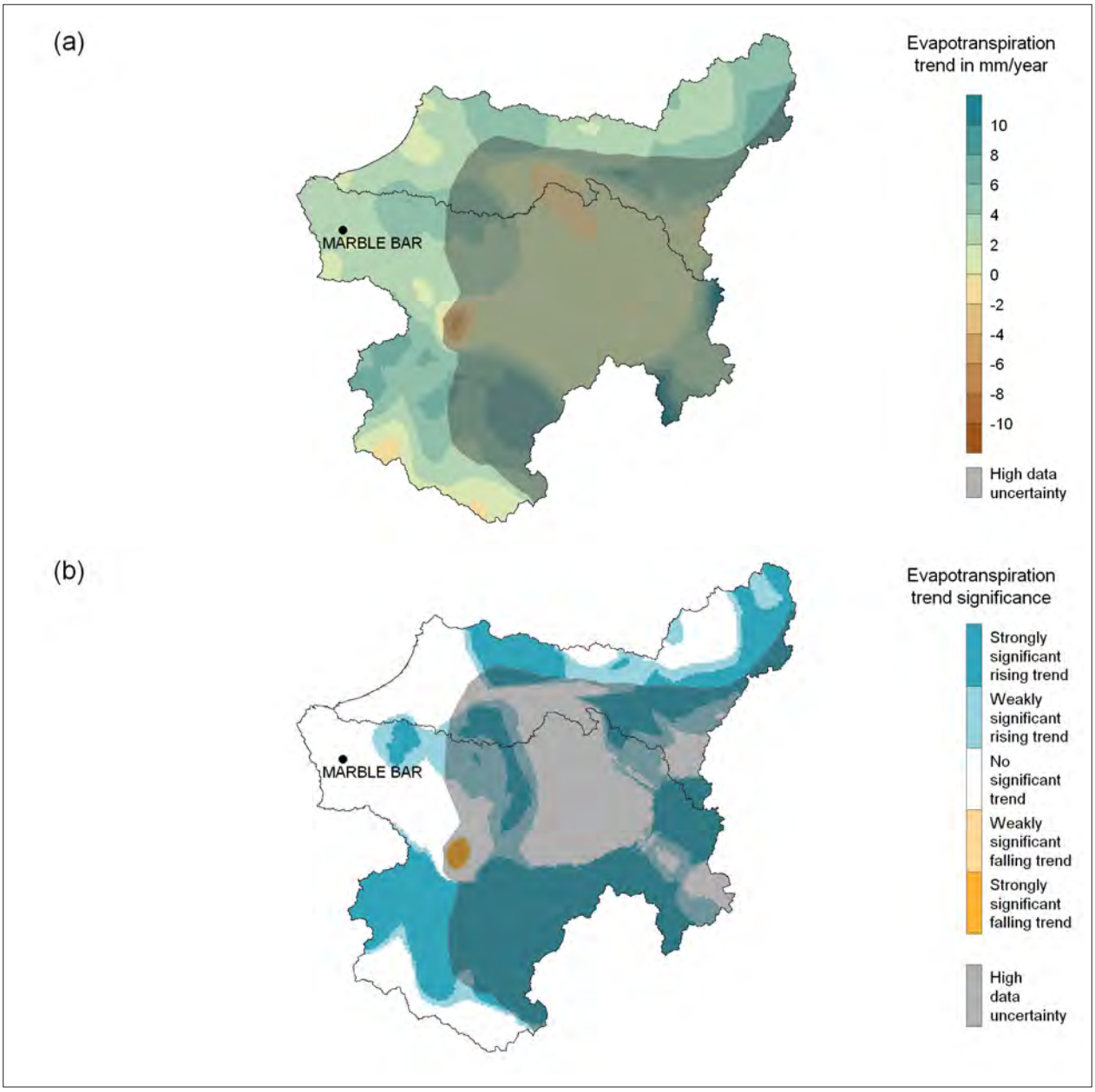


Figure 12.18 Spatial distribution of (a) trends in annual evapotranspiration from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the North Western Plateau region

12.4.3 Landscape water yield

Modelled landscape water yield for the North Western Plateau region for 2011–12 is estimated to be 26 mm. This is 136% above the region's long-term (July 1911–June 2012) average of 11 mm. Figure 12.19a shows the spatial distribution of landscape water yield for 2011–12, which is similar to the annual rainfall distribution (Figure 12.13a, note the difference in the scale of the legend).

The decile-ranking map for 2011–12 (Figure 12.19b) shows above average to very much above average landscape water yields, similar to what can be seen in the rainfall patterns of Figure 12.13b. Very much above average water yields are found across much of the data-sparse southeast, but these results should be used with caution as they are model results generated with highly uncertain rainfall data.

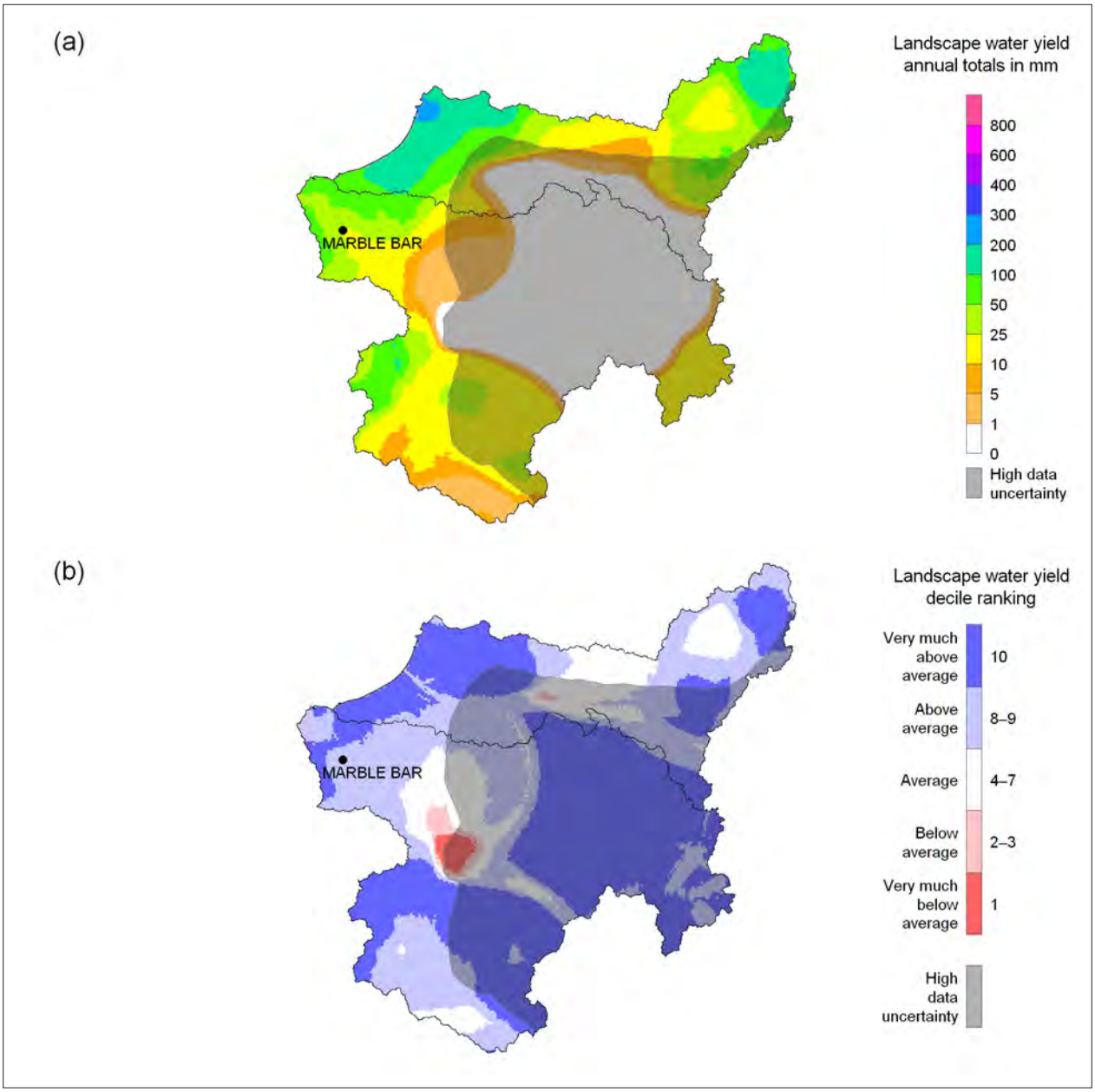


Figure 12.19 Spatial distribution of (a) modelled annual landscape water yield in 2011–12, and (b) their decile rankings over the 1911–2012 period for the North Western Plateau region

Landscape water yield variability in the recent past

Figure 12.20a shows annual landscape water yield for the North Western Plateau region from July 1980 onwards. Over this 32-year period, annual landscape water yield was 21 mm, varying from 4 mm (1989–90) to 64 mm (1999–2000). Temporal variability and seasonal patterns (over the summer and winter periods) since 1980 are presented in Figure 12.20b.

Landscape water yield is consistently higher during the summer period compared to the winter period. Rainfall obviously is the major force behind landscape water yield and the temporal variability closely resembles the variability in rainfall. Again, the coefficient of variation (standard deviation divided by the mean) of the annual data is high compared to most other regions.

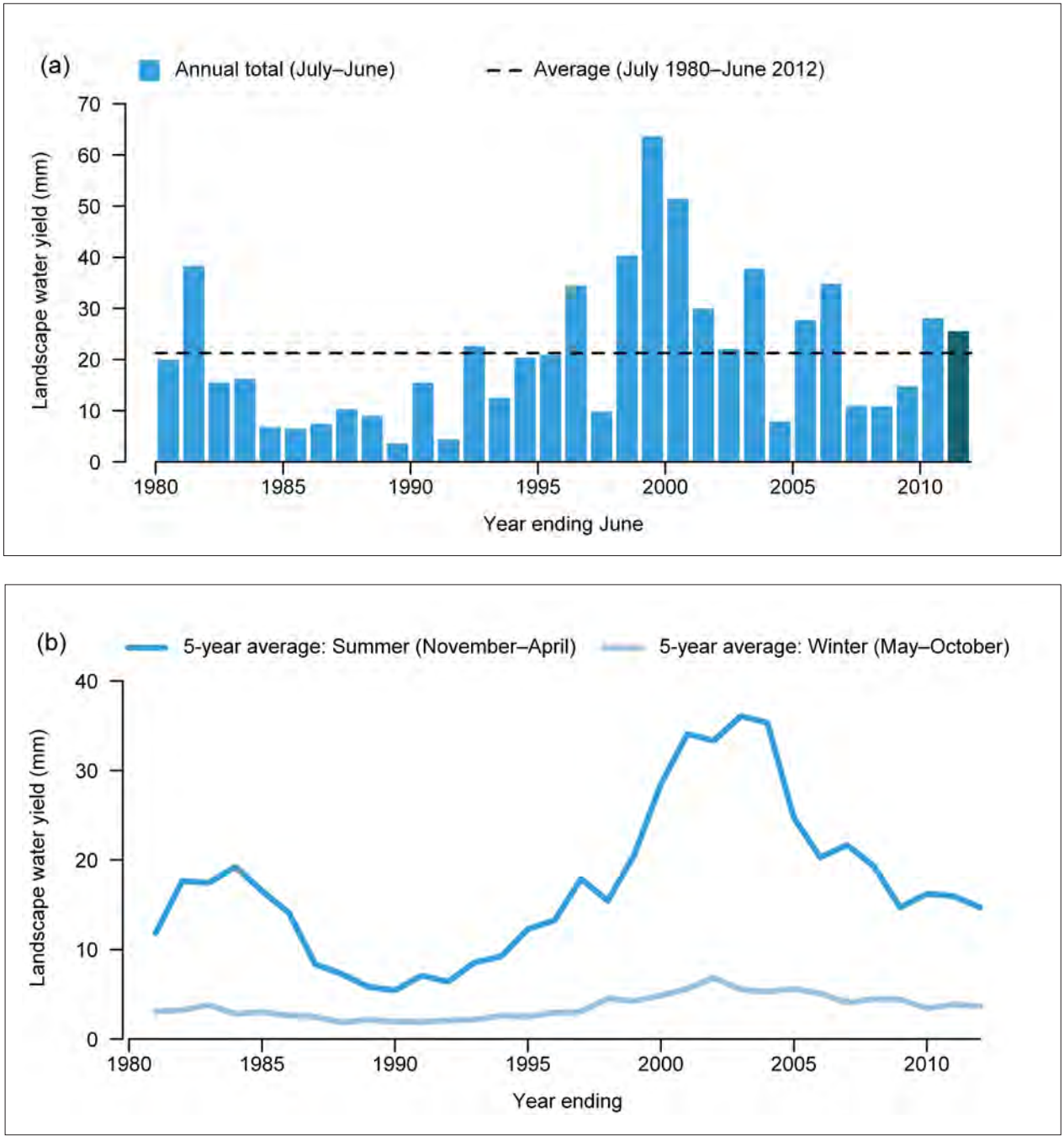


Figure 12.20 Time-series of (a) annual landscape water yield, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the North Western Plateau region

Recent trends in landscape water yield

Figure 12.21a shows the spatial distribution of the trends in modelled annual landscape water yield for 1980–2012. These are derived from linear regression analyses on the time-series of each model grid cell. The statistical significance of the trends is provided in Figure 12.21b.

Figure 12.21a shows that there is no obvious trend in most of the region with the exception of the far northeast where landscape water yield increases towards the eastern border of the region. Figure 12.21b confirms the significance of these trends and shows some strong signals mainly in the southwest of the region; however, trends here only just reach 1 mm/year.

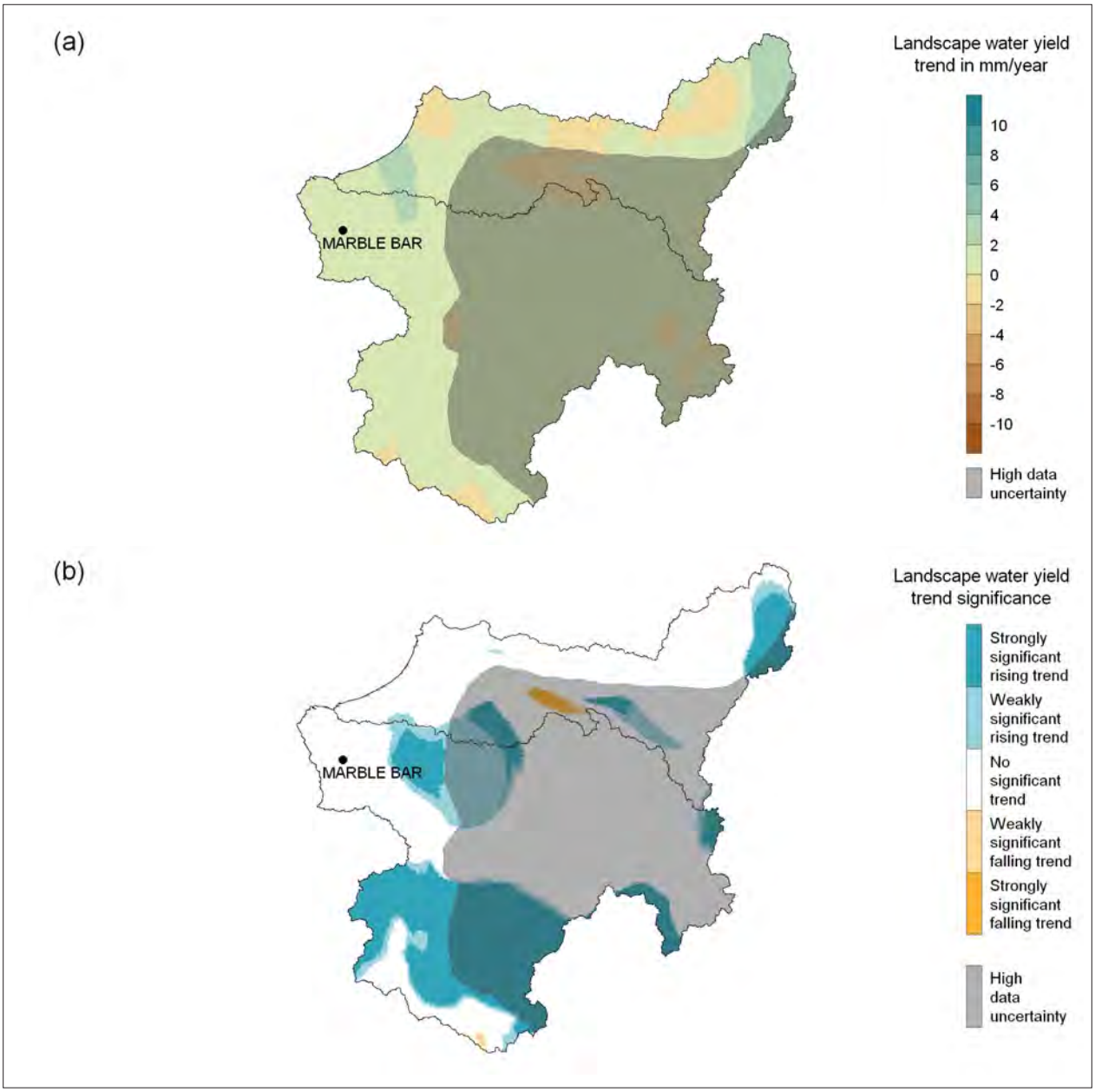


Figure 12.21 Spatial distribution of (a) trends in annual landscape water yield from 1980– 2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the North Western Plateau region

12.5 Surface water and groundwater

This section examines surface water and groundwater resources in the North Western Plateau region in 2011–12. Rivers and wetlands are discussed to illustrate the state of the region's surface water resources. The region's watertable aquifers and salinity are described. No data was available at the Bureau in a suitable format for a detailed analysis on individual aquifers.

There are no major storages located in the region.

12.5.1 Rivers

There are two river basins in the North Western Plateau region. The De Grey River basin covers an area of 477,000 km^2 and the Sandy Desert basin is 239,000 km^2 in size.

The region has some limited surface water resources present in the western part of the region (Figure 12.22). The coastline consists of tide-dominated strand plains and tidal creeks. Some dry lakes are scattered over the region, but aeolian landforms including dunes and sand plains dominate the landscape.

Almost all rivers are ephemeral, ending up in desert country or salt lakes, except for the De Grey River basin. All streams flow only after heavy rains, which occur infrequently.

12.5.2 Flooding

Heavy rainfall in January associated with an active monsoon brought tropical cyclones *Heidi* and *Iggy* to the region. These tropical cyclones caused moderate to major flooding particularly in the Shaw and Coongan rivers. Major floods affected the Nallagine and De Grey rivers in March with the passage of tropical cyclone *Lua* (Figure 12.23).

12.5.3 Wetlands

There is one Ramsar-listed, internationally important wetland in the North Western Plateau region and there are a number of wetlands of national importance in the region mentioned in the *Australian Directory of Important Wetlands* (www.environment.gov.au/water/topics/wetlands/database/diwa.html). The wetlands vary from coastal floodplains, lakes and tidal flats to inland ephemeral lakes and river floodplain systems (Figure 12.24).

The Eighty Mile Beach Ramsar site mainly consists of tidal flats, which sometimes extend up to 5 km in width. It is a highly important retreat for many species of (migrating) shorebirds.

No detailed assessment on the inflows of selected wetlands has been performed for this region.

Birdlife on the Eighty Mile Beach, Western Australia | Gayle Partridge

Figure 12.22 Rivers and catchments in the North Western Plateau region

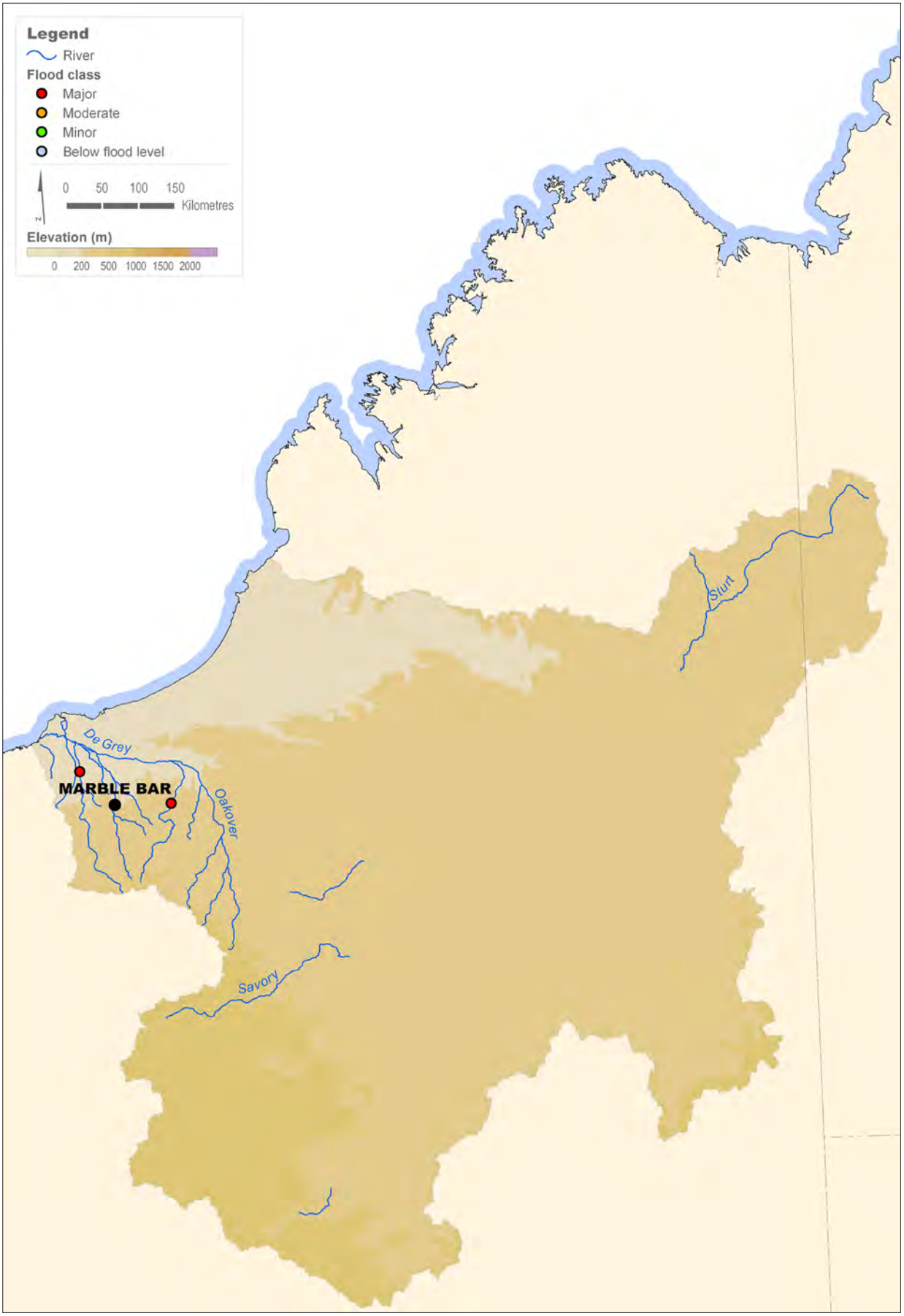


Figure 12.23 Flood occurrence in 2011–12 for the North Western Plateau region

Figure 12.24 Location of important wetlands in the North Western Plateau region

12.5.4 Hydrogeology

The hydrogeology is dominated by a large area of outcropping fractured basement rock in the west and east of the region. The associated groundwater systems typically offer restricted low volume water resources. Other important hydrogeological groups are the Mesozoic sediments through the centre of the region and the surficial sediments in-filling palaeovalleys. These groups are likely to offer more reliable groundwater resources (Figure 12.25).

The watertable aquifers present in the region are given in Figure 12.25 below. Groundwater systems that provide more potential for extraction are labelled as:

- Mesozoic sediment aquifer (porous media — consolidated); and
- surficial sediment aquifer (porous media — unconsolidated).

12.5.5 Watertable salinity

Figure 12.26 shows the classification of watertable aquifers as fresh (total dissolved solids (TDS) < 3,000 mg/L) or saline (TDS ≥ 3,000 mg/L) according to watertable salinity. As shown, most parts of the region are considered to have fresh goundwater. Saline groundwater occurs in localised areas along the major drainage lines in the alluvial sediments.

12.5.6 Groundwater management units

The groundwater management units within the region are key features that control the extraction of groundwater through planning mechanisms. Figure 12.27 shows that the groundwater management units within the region include Canning–Kimberley, East Murchison, Goldfields and Pilbara.

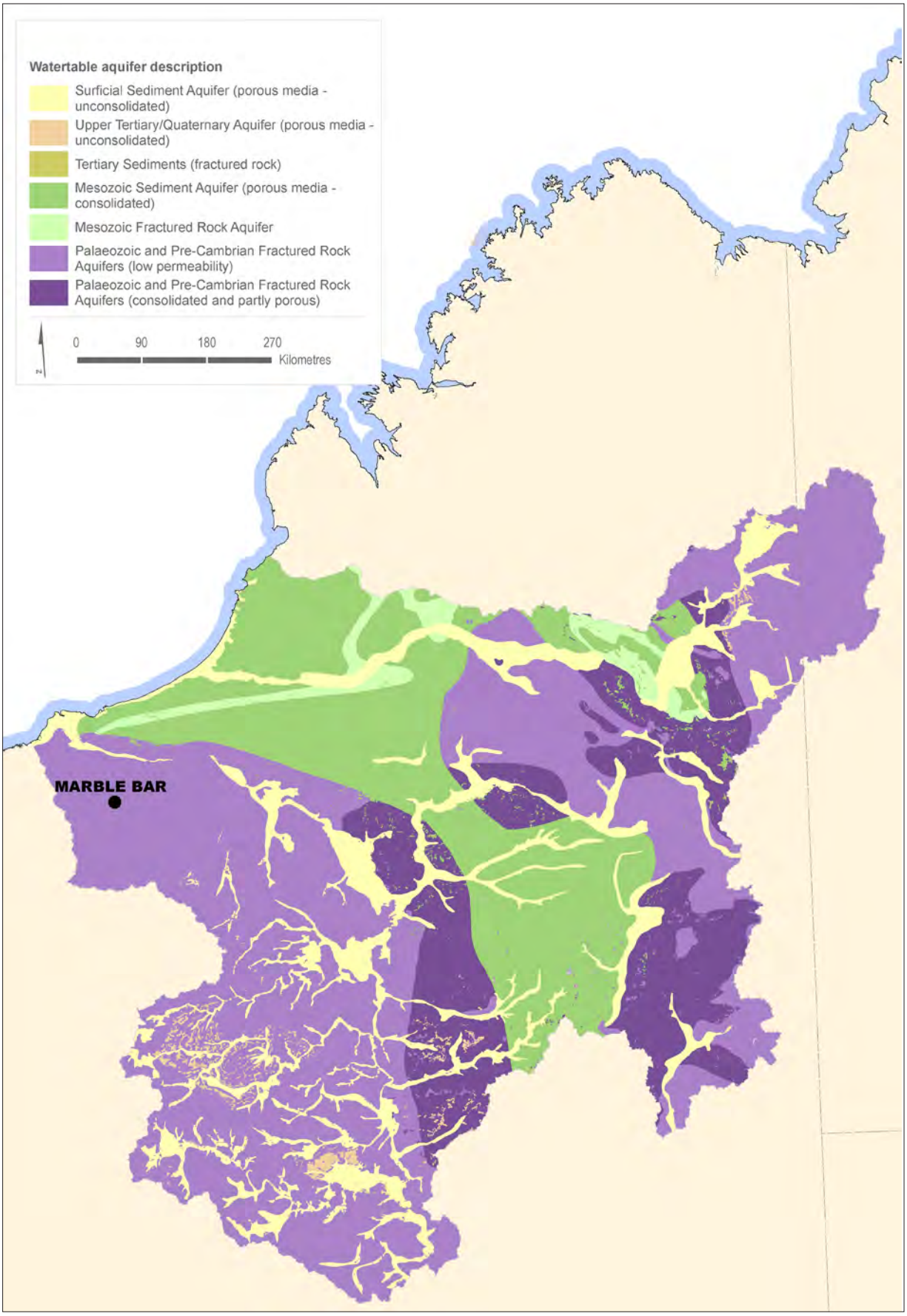


Figure 12.25 Watertable aquifers of the North Western Plateau region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

Figure 12.26 Watertable salinity classes of the North Western Plateau region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

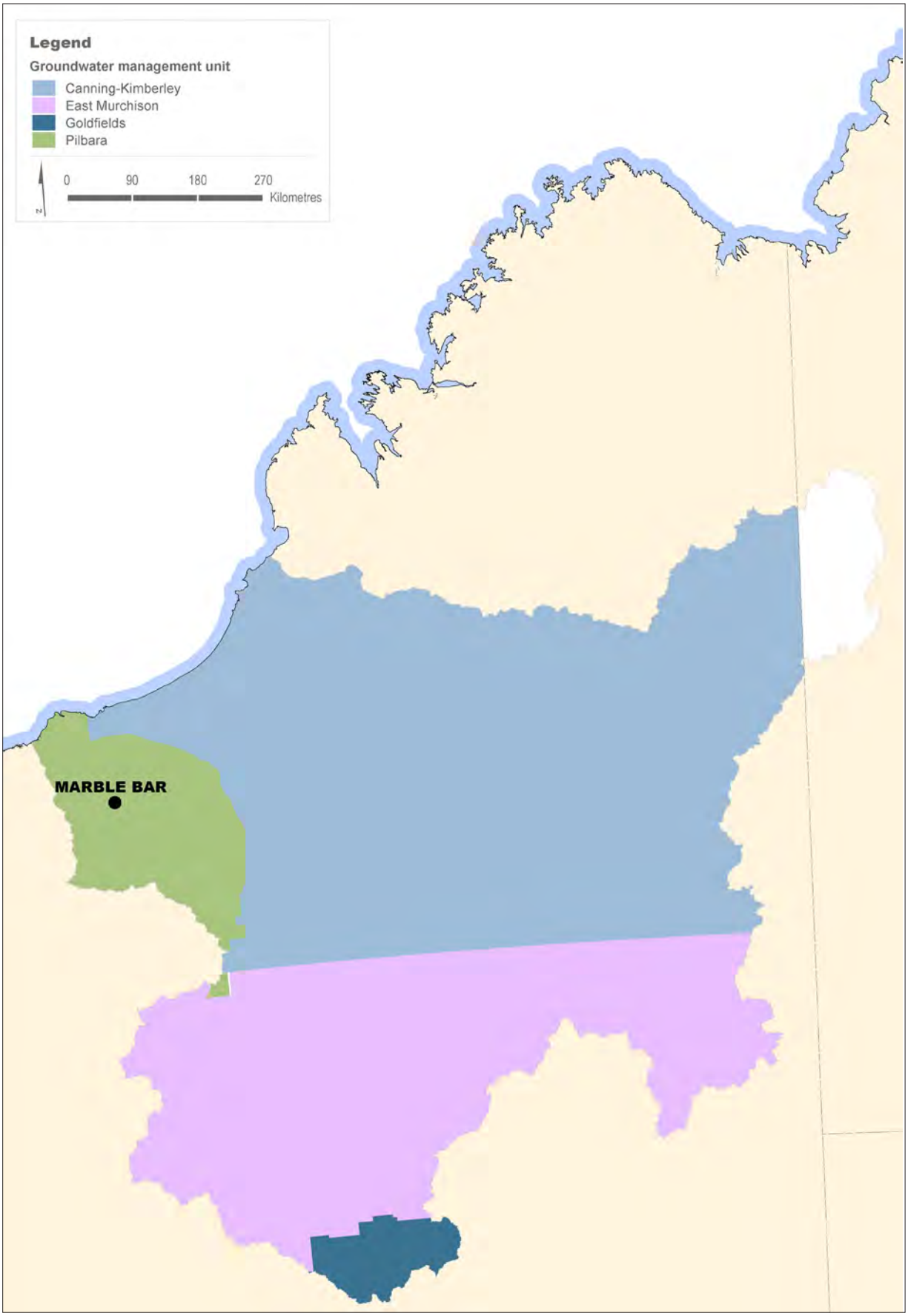


Figure 12.27 Groundwater management units in the North Western Plateau region; data extracted from the National Groundwater Information System (Bureau of Meteorology 2013)