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SUPPLEMENTARY MATERIAL

The emerging threat of hot drought in Western Australia

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Maps showing hot drought extent in recent years

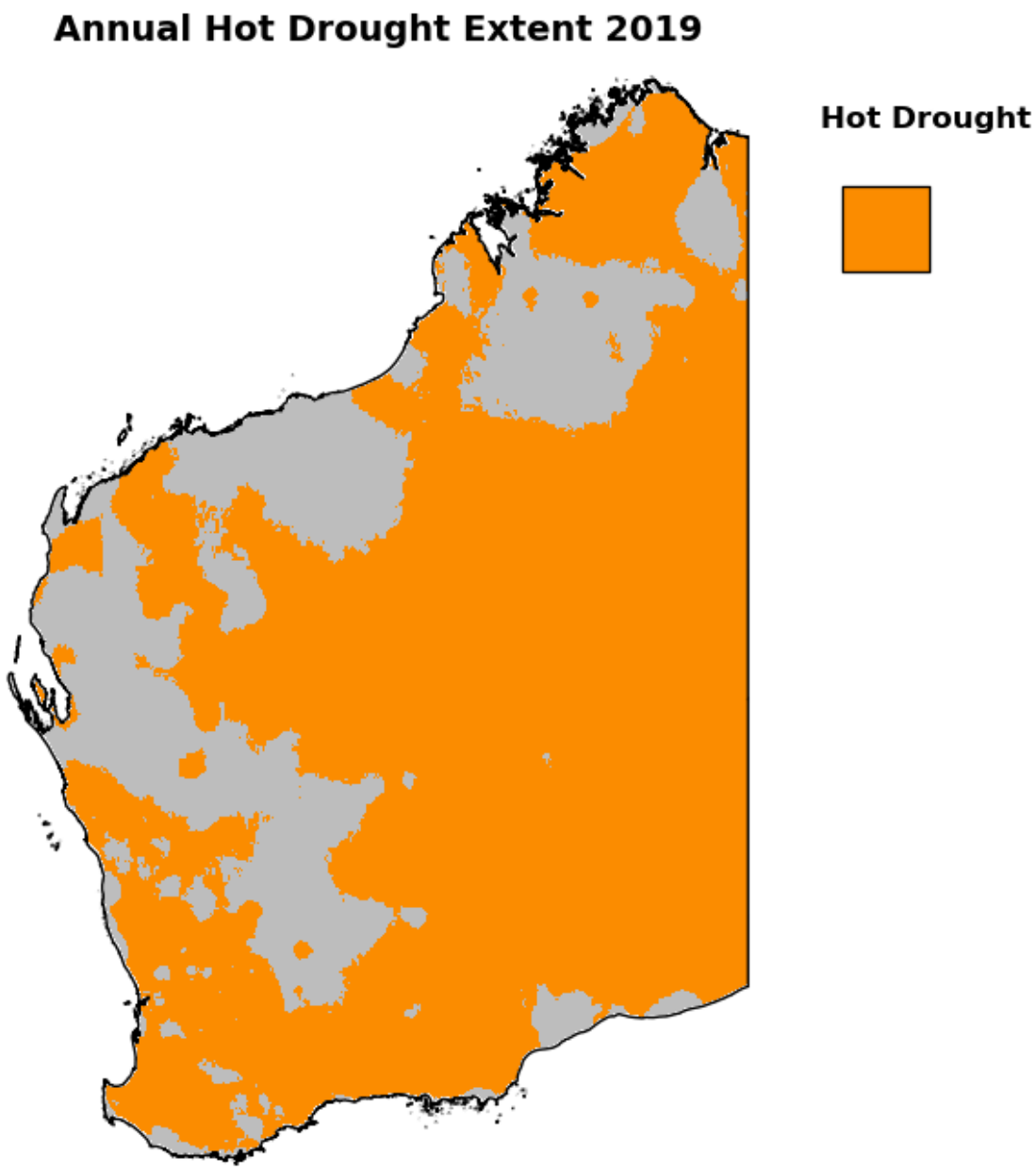


Figure S6. Annual hot drought extent across Western Australia in 2019.

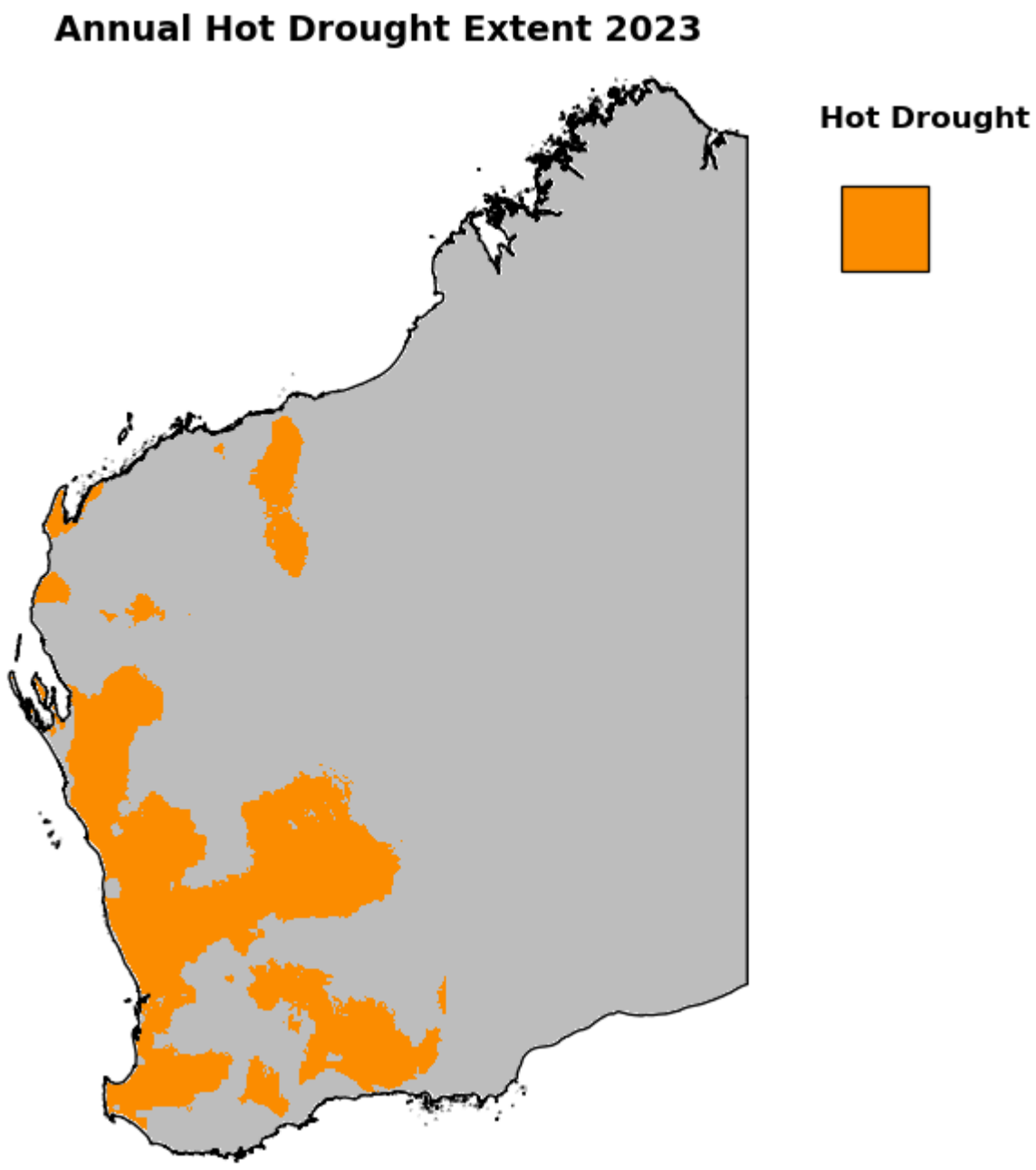


Figure S7. Annual hot drought extent across Western Australia in 2023.

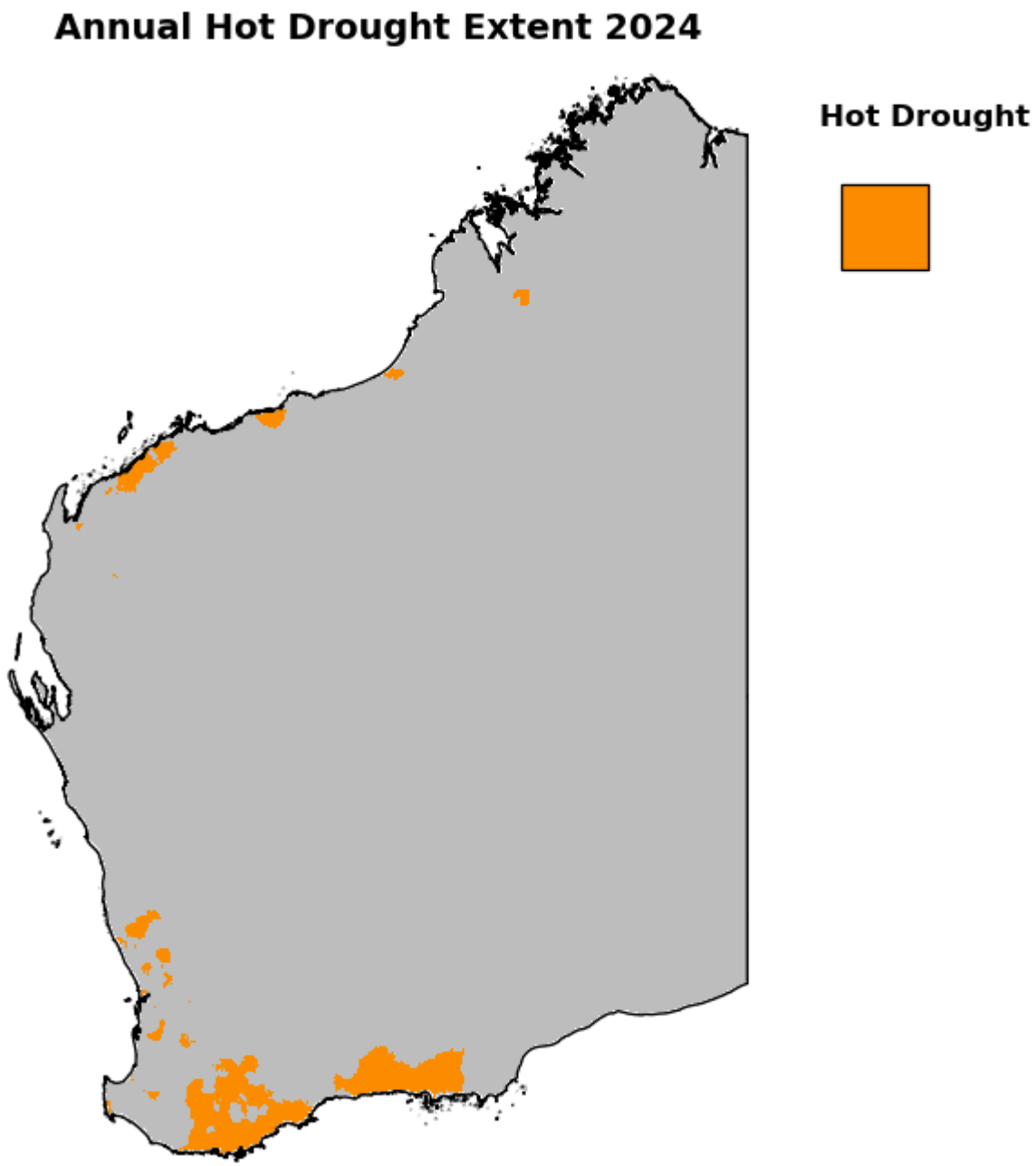


Figure S8. Annual hot drought extent across Western Australia in 2024.

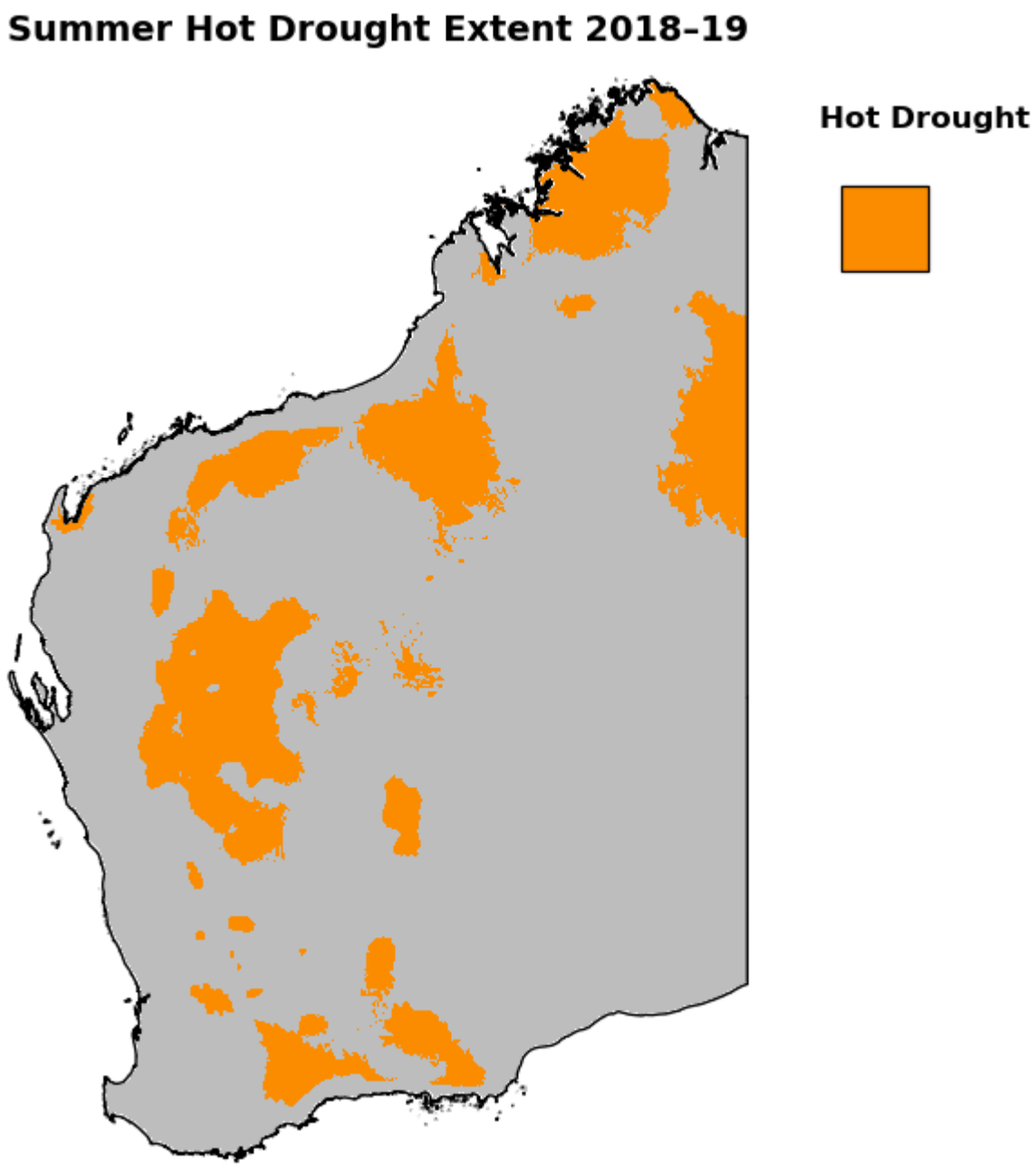


Figure S9. Summer hot drought extent across Western Australia in 2018–19.

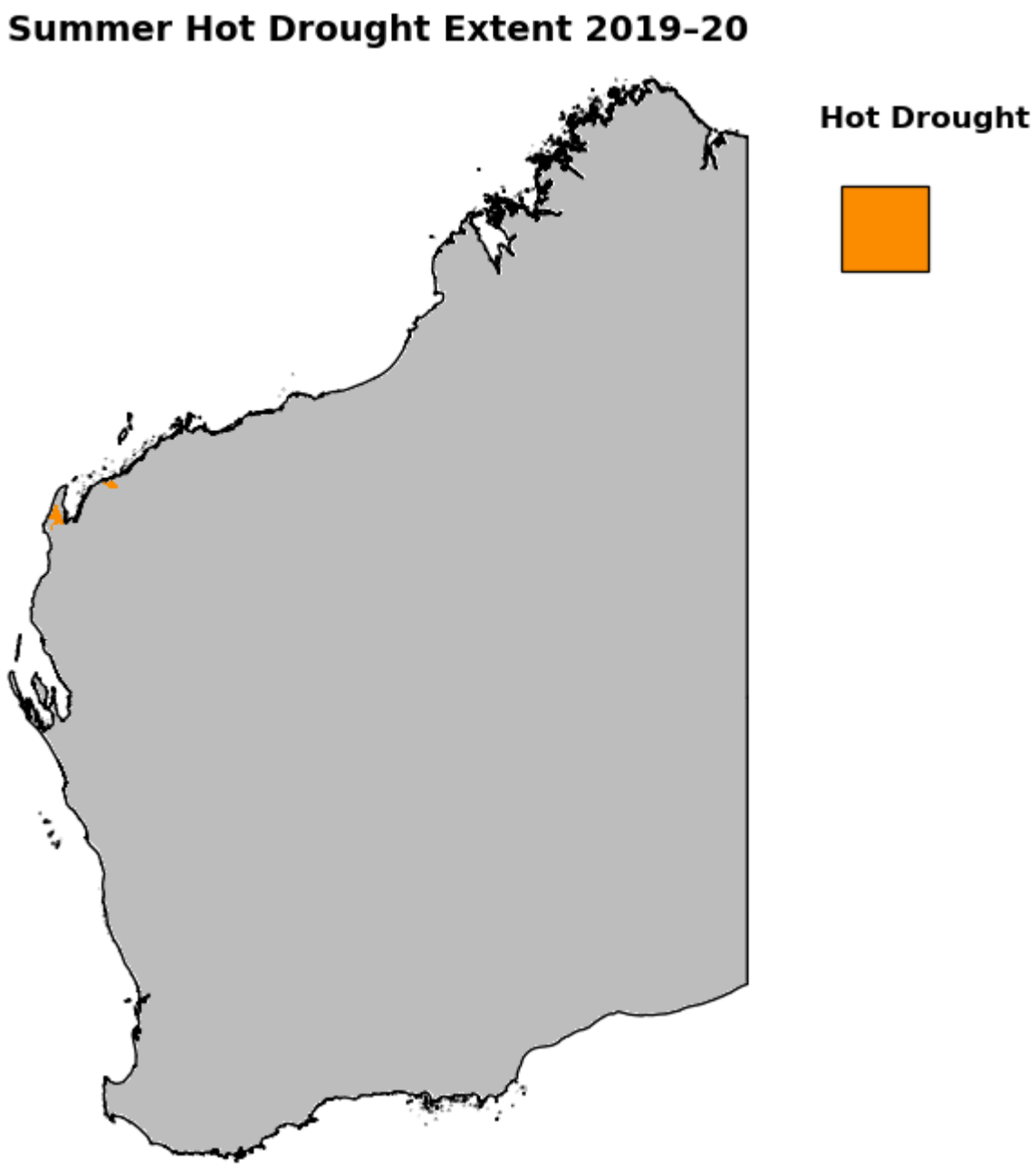


Figure S10. Summer hot drought extent across Western Australia in 2019–20.

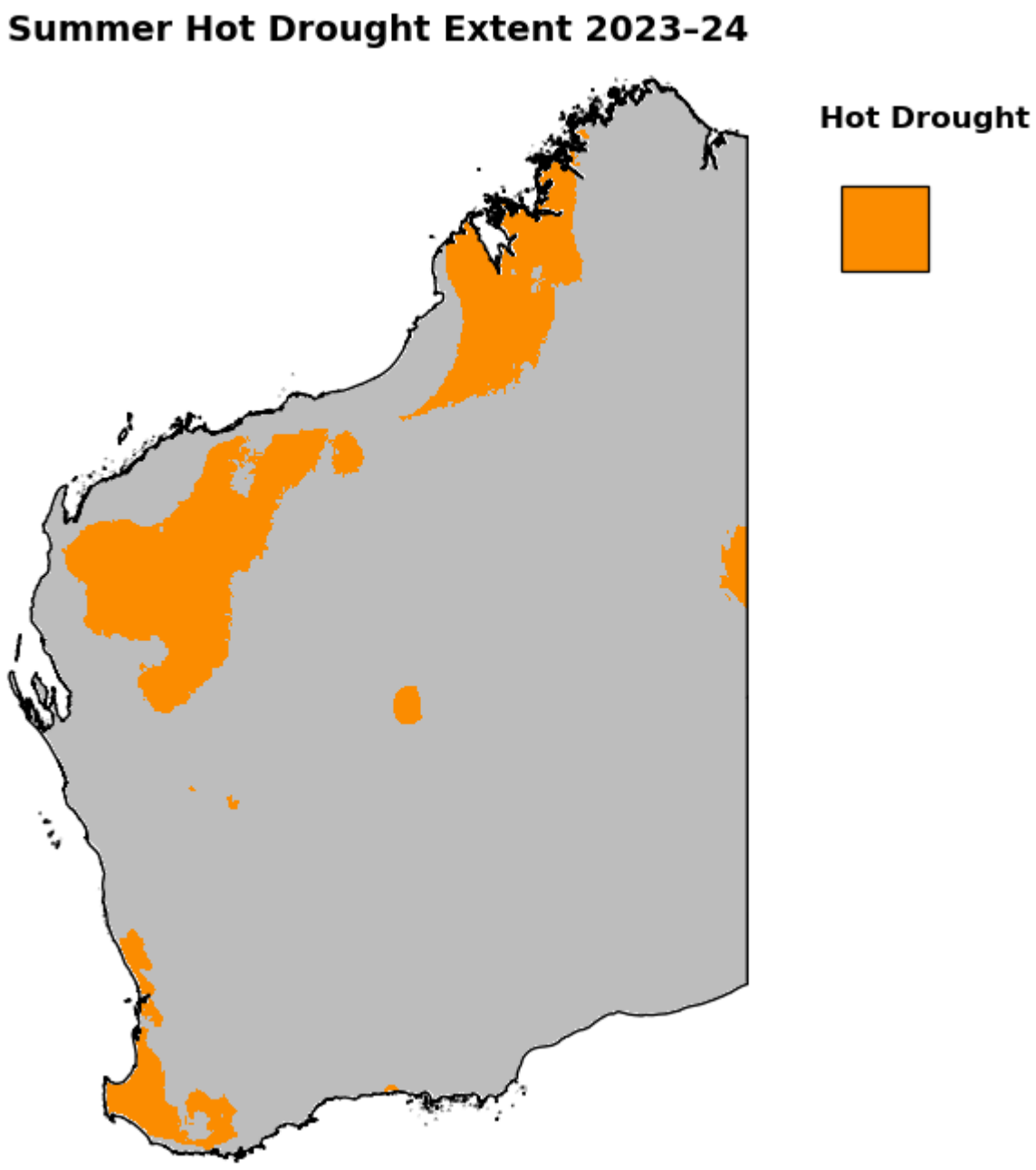


Figure S11. Summer hot drought extent across Western Australia in 2023–24.

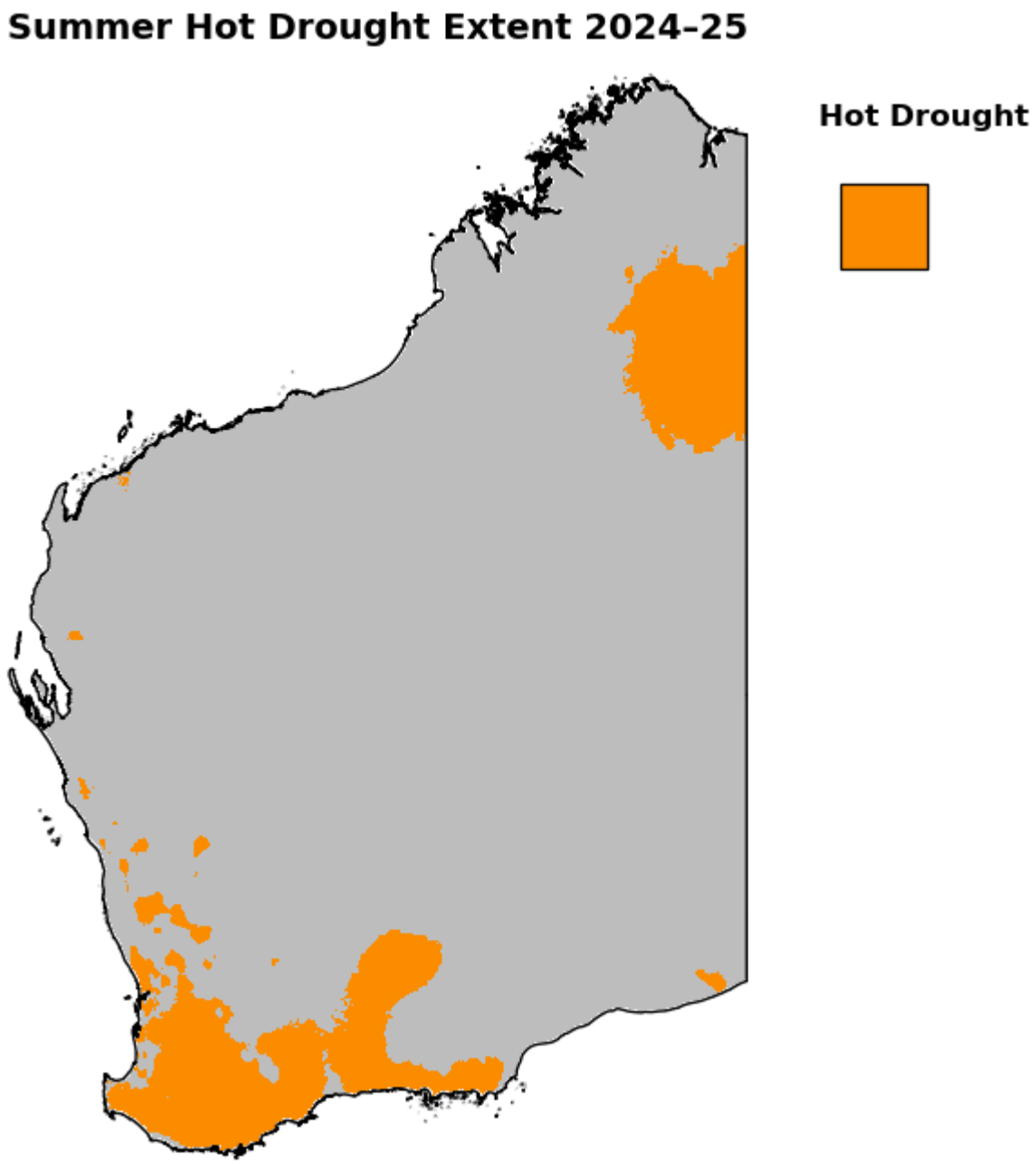


Figure S12. Summer hot drought extent across Western Australia in 2024–25.

Climate conditions for Paruna and Karakamia in 2023–24

Annual rainfall at both Karakamia and Paruna in 2023 was well below average (562 mm c.f. long-term average of 846 mm) and the 2023–24 summer was the driest on record, with rainfall 80% below the seasonal average (BOM 2025). Mean rainfall for the October to April period is 144 mm but only 28 mm fell between October 2023 and April 2024. The extreme low rainfall period coincided with the highest monthly mean maximum temperatures on record, 1–4.5°C above average (BOM 2025). These hot, dry conditions had severe impacts on native vegetation across the Darling Range and both Karakamia and Paruna were affected. Staff working on both properties began noticing vegetation

browning off in early 2024. This was followed by apparent tree mortality and collapse of the shrubby understory layers across large areas at Paruna. Vegetation condition continued declining until early June when the first rains began falling (approximately two months later than is usual).

Paruna Vegetation Condition Assessments Detailed Methods and Results

The severity, extent and recovery from observed drought-induced vegetation collapse were monitored at fixed photo points across Paruna Wildlife Sanctuary (n = 84; Figure S1).

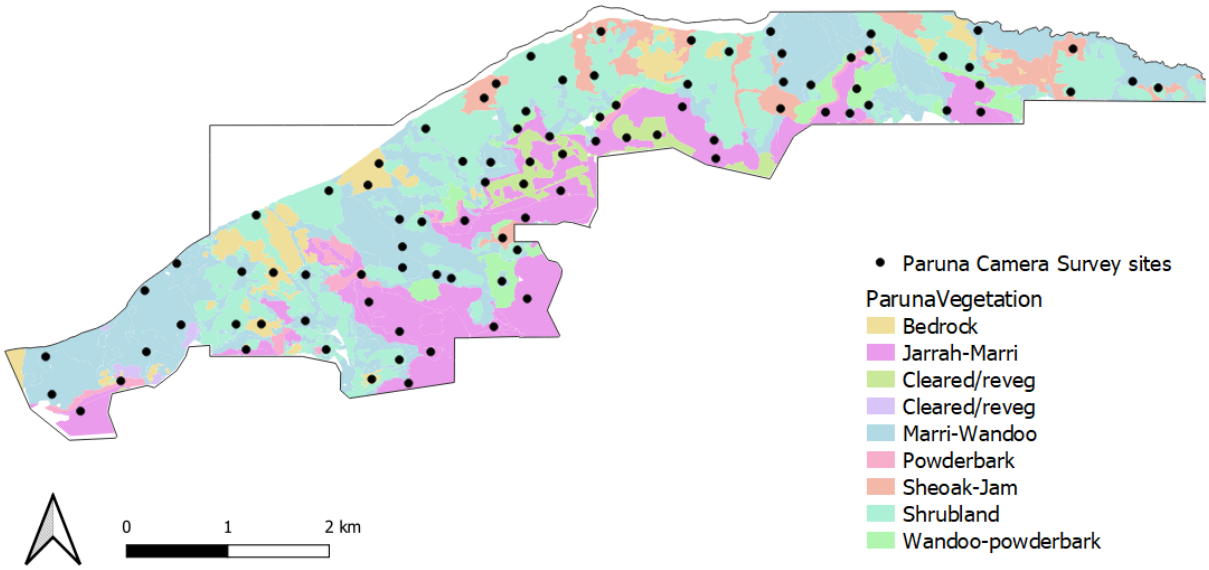


Figure S1. Paruna Sanctuary-wide Camera Survey sites used for the drought condition assessments.

At each site, the percentage of vegetation with (1) unaffected crowns, no or minimal evidence of stress, (2) moderately affected crowns, predominantly dry and discoloured leaves but still retaining green foliage, and (3) severely affected crowns, complete crown dieback and no live healthy foliage, was estimated for the tree and shrub layers. Percent estimates were grouped into the following categories: < 5%, 5–25%, 25–50%, 50–75%, > 75%. The percent estimate categories for moderately and severely affected trees and shrubs were then converted to a scoring system to facilitate comparisons (Table S1). The maximum score a quadrat/site could receive was 8 (i.e. >75% severely affected vegetation or 50-75% moderately or severely affected vegetation and the remaining 5-25% severely affected). The drought impact scores were summed across the moderately and severely affected categories. Trees and shrubs were assessed and scored separately.

Scores between 0 and 2 were taken to represent sites that were unaffected by the drought. Scores between 3 and 5 indicated sites with minor to moderate impacts. Scores above 6 indicated sites that were severely drought affected. The tree and shrub impact scores were then summed to obtain a total drought impact score. For this, scores between 0 and 4 were taken to represent sites that were unaffected by the drought, scores between 5 and 10 indicated sites with moderate impacts, and scores above 11 indicated sites that were severely drought affected. The maximum possible score was 16.

Table S1. Conversions of percent categories taken in the field to scores suitable for analysis.

Percent category	Score for moderately affected vegetation	Score for severely affected vegetation
< 5	0	0
5 – 25	1	2

25 – 50	2	4
50 – 75	3	6
> 75	4	8



Figure S2. Typical Jarrah site at Paruna Wildlife Sanctuary, JM(Jarrah-Marri)4, showing the unaffected tree layer and mainly unaffected shrub layer. Some Parrot Bush with complete crown dieback is visible, but this may not be drought-induced decline. Photo taken in May 2024 (credit: Bryony Palmer/AWC).



Figure S3. A typical Cleared/Reveg site at Paruna Wildlife Sanctuary, CR(Cleared-Reveg)2, showing largely unaffected, though very depauperate, shrub and tree layers. Photo taken in May 2024 (credit: Bryony Palmer/AWC).



Figure S4. Wandoo sites MW4 (Marri-Wandoo; left) and MW5 (right) at Paruna Wildlife Sanctuary. MW4 is typical of most Wandoo sites, showing mostly unaffected trees but a severely stressed shrub layer. MW5 was an outlier, likely due to its buffered location along an ephemeral creekline, and was largely unaffected by drought. Photo taken in May 2024 (credit: Bryony Palmer/AWC).

Drought-affected sites were almost all located on the steepest hillsides, especially on north and north-east facing slopes, and tended to be higher in the landscape (Figure S5). This was particularly the case for severely impacted sites. Almost all the unaffected sites were located either on top of the escarpment or in the parkland cleared area on the west end of the sanctuary (Figure S5). The majority of the severely drought-affected Granite and Shrubland habitats are located on the steep hillsides, while the generally unaffected Jarrah habitat is primarily found on top of the escarpment.

Across all sites, Wandoo (*Eucalyptus wandoo*) and Marri (*Corymbia calophylla*) were the most affected by drought and accounted for the majority of trees showing complete crown dieback or severe stress. Jarrah (*E. marginata*) is the other dominant tree species across most of the sanctuary but very few individuals of this species were impacted. Sheoak (*Allocasuarina fraseriana*) were present at only a few sites, but most were severely impacted by drought.

Trymalium odoratissimum is the dominant shrub species at most Wandoo and Shrubland sites and was severely affected across the sanctuary, with most plants showing complete crown dieback and the remainder stressed. The Granite and some Wandoo sites have a diverse shrub layer and at these sites almost all species were severely affected. Many severely affected Parrot Bush (*Banksia sessilis*) and Pingles (*B. squarrosa*) were also recorded, mostly from Jarrah sites, however the contribution of drought to their decline was hard to assess as death may have been the result of natural senescence of these short-lived species.

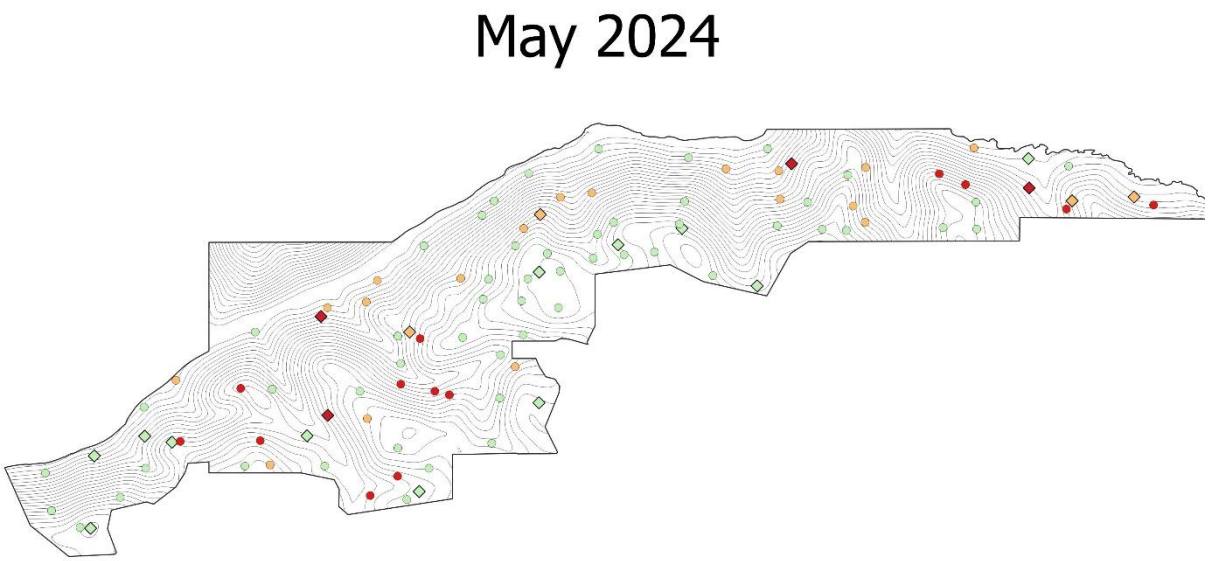


Figure S5. Overall drought impact scores at Paruna Wildlife Sanctuary in May 2024 (circles are surveyed sites). Red indicates severe impact, orange indicates moderate impact, and green indicates no impact.