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Ecological thresholds of concern in the Murray-Darling Basin

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Abstract: Future climate in the Murray–Darling Basin is expected to result in higher temperatures, reduced mean rainfall and greater extremes in both drought and flood events, with an expected overall reduction in inflows to the Basin's rivers. Many habitats and species within the Basin are likely to be exposed to a range of novel conditions that are not represented by the historical climate, which is likely to put species and habitats under greater pressure. To address existing knowledge gaps, the Sustainable Yields 2 Module 4 – Ecological Thresholds of Concern project completed: 1) a collation of information related to ecological thresholds, 2) development of a framework for assessment of thresholds under a range of plausible future climate scenarios, and 3) an interpretation of change at the basin scale including and assessment of the potential ecological risks of climate change in the Basin. At the time of the project, only hydroclimate data was available (including temperature, rainfall and a derived drought index) as hydrology data was still under development. This represents a critical next step for future work. Here we provide an overview of the assessment framework and a demonstration with sample results.

Keywords*: Sustainable Yields 2, Murray-Darling Basin, climate change, ecological thresholds, hydroclimate*

1. INTRODUCTION AND METHODS

Understanding the potential ecological consequences of future climate change requires insight into the climate-related processes that may pose increasing risks to ecology, where these risks are likely to occur, and the specific components of ecology that are likely to be affected. We considered this by determining a set of quantified ecological thresholds, based upon multiple lines of evidence including ecological data and scientific knowledge, for key ecological indicators across the Basin from the themes of vegetation (6 indicators), fish (3 indicators) and waterbirds (3 indicators, 1 assessed). These indicators include species and species groups with a range of different ecological needs, life histories, and habitat associations and distributions, as well as for alignment with the Basin Plan. Indicators were also required to have a sufficient knowledge base to support assessment.

The project used the latest hydroclimate projections informed by CMIP6 Global Climate Models (GCMs) generated in Module 1 of Sustainable Yields 2 (Chiew et al., 2025). These were used to explore a suite of climate hazards (such as extreme heat days or drought durations) specific for each of the ecological indicators. While considering this hydroclimate data extends the science base and understanding around important hydroclimatic hazards beyond flow, the current work is intended to be complementary to contributions which include flow. The plausible range of future hydroclimates are defined as those within the 10^{th} (represented by scenario S4), median (S5) and 90th (S6) percentile bounds of all the GCMs.

For each indicator, their *vulnerability* to these climate hazards was described and quantified. This consisted of developing *metrics* that define the magnitude, duration, and in some cases timing of events, and *thresholds* that defined either an inter-event period or a frequency of events over a given period, that if exceeded, would result in concern for the indicator. The distributions of the indicator species from ALA (Atlas of Living Australia, 2024) or ANAE (DCCEEW, 2021) were intercepted with HydroATLAS level 10 polygons (Lehner, B. and G. Grill, 2013) to create assessment units for the analysis. Each of the 7,278 assessment units of the Basin where each indicator was distributed was assessed for exceedance of the indicators metrics and thresholds using the climate data from the baseline historical climate and each of the plausible future scenarios. This analysis resulted in a value of *severity* for the indicator for each of its assessment units.

The dominant hazard resulting from the scenarios was identified (Figure 1B). As a final step, the severity of exposure under each of the plausible future climate scenarios was assessed as relative change compared to the historical baseline – thereby providing a spatial value of the level of concern associated with the relative change under the scenario (see example in Figure 1C).

2. RESULTS AND DISCUSSION

The results indicate that the Basin faces a suite of changes associated with potential future climate change which is likely to generate novel hydroclimatic conditions that will have direct relevance to ecological systems and to achieving Basin Plan objectives. Overall, drought was the most significant hazard in extent and magnitude assessed across the indicators (see example in Figure 1b), while temperature and rainfall changes resulted in mostly (but not exclusively) secondary levels of concern in comparison, thereby highlighting the importance of water scarcity as a threatening process under plausible future hydroclimate change.

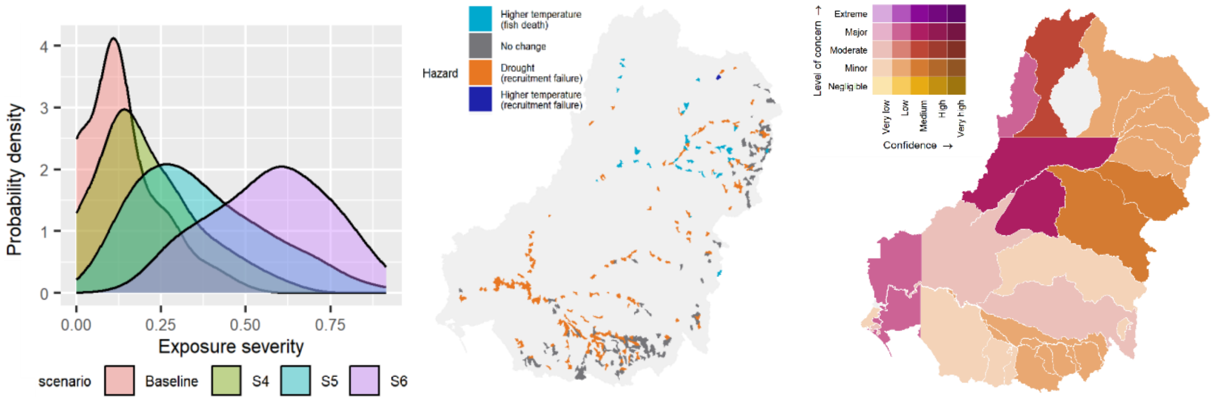

Figure 1 Example results showing A) Murray cod exposure to their drought hazard under different scenarios shown from 0 to 1, with 0 indicating no exposure and 1 indicating exposure for 100% of the time period; B) map showing the hazard with the greatest change in exposure for Murray cod; and C) Aggregated level of concern and confidence for the fish theme to the hazards of high temperatures and drought

In locations where temperature was identified as the dominant hazard for the assessed indicators, this was predominantly in the northern Basin, where there is likely a smaller margin between current conditions and thermal maximum thresholds. These effects were often (but not only) in conjunction with the slightly wetter and warmer scenario (S4), in which increased rainfall likely helps mitigate some of the impacts of water scarcity projected in the other scenarios. This highlights that uncertainty associated with the climate future could have a tangible impact on the nature and magnitudes of hazards that are experienced.

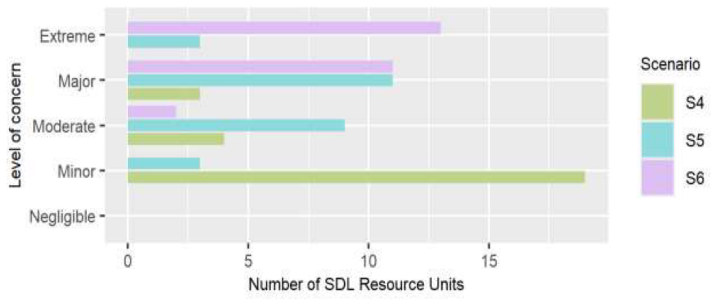

Figure 2 The number of SDL Resource Units for each level of concern by scenario for the fish theme

It is important to note that much of this work has high uncertainty originating from a range of sources. This is documented in Stratford. et al. (2025) and includes the knowledge base, local context and variability, within the modelling framework, and also in association with the trajectory of future climate change. However, the results provide important insights into the range and extent of potential increases in climate related hazards impacting ecology across the Basin. While developing an understanding of the risks associated with changes in hydroclimate is important, and aimed to improve understanding of key research gaps, the critical importance of hydrology in the achievement of Basin outcomes and management needs to be recognised in the interpretation of results.

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