<u>An environment for growing - the climate and conditions for native vegetation as a consequence of Climate change in North- East Victoria</u>

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Introduction

In Australia, climate is emerging as one of the biggest drivers of natural resource condition and associated management and use. Climate change in Australia is expected to effect growth conditions through direct increases in elevated carbon dioxide (CO2) and average temperature, and through increases in the variability of climate, with potential to increase the occurrence of abiotic stresses such as those from heat, drought, waterlogging and salinity (Chapman et. al, 2012). Although the climate in the North East region of Victoria (the North East) is highly variable, it is anticipated that the climate will be warmer and drier with heavier downfalls of rain when it does occur, especially during Summer and Autumn (NECMA, 2016).

North East Victoria is bounded by the Murray River in the north, the Victorian Alps in the south, the NSW border in the east and the Warby Ranges in the west (NECMA, 2022). It takes in the local government municipalities of Wodonga, Indigo, Wangaratta, Alpine and Towong, plus parts of the Moira and East Gippsland shires (NECMA, 2022). Considerable information is available for the review of climate change and related topics at a national, state or large area scale; however, it is not necessarily specific to the North East of Victoria (our area of focus). Nevertheless, much of this information is relevant and can assist us to make connections or inferences about similar expected patterns. We also recognise that the content of this article is broad, and many specific areas of study exist.

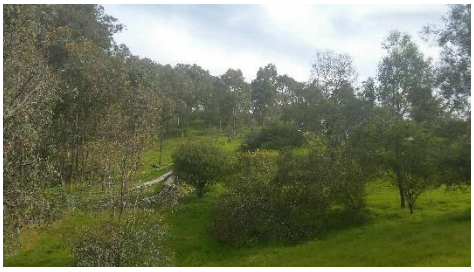

Figure 1- North East Victoria is home to a beautiful landscape, Photo Sophie Enders

Australian plants and animals are adapted to a high degree of environmental variability including cycles of hot and dry years followed by cool and wet years (DELWP, 2022). Whilst the fossil record shows that species can shift in response to climatic changes, there are limits to how much vegetation can adapt (DELWP, 2022) particularly under the current projected rates of change (DELWP, 2022). Even under the projection of only 1.5 degree warming this will be 25 times faster than the change from the previous 'cold period' (DELWP, 2022). The continued survival of a species will also depend on its reproductive capacity, the survival of newly germinated individuals through their life cycles and the capacity of longer-lived individuals in the patch to compete for resources (Woodward, 1992). All patches suffer disturbance at a range of temporal and spatial scales; the disturbances vary in type from the physical, such as wind damage, to the biological, such as those caused by pathogens and herbivores (Woodward, 1992). The impacts of disturbance may have significant effects on the survival of individual plants and may also influence the functioning, for example the hydrology, of the whole patch (Woodward, 1992).

Within the context of climate change, it is important to quantify the stability of ecosystems with respect to climate anomalies, acknowledging that ecosystem stability may change over time. At the moment a disturbance occurs (such as climate change), the vegetation state may change, where the ability of the ecosystem to withstand the disturbance is referred to as resistance (Keersmaecker et al., 2017). However, sometimes the disturbance is strong enough or changing conditions have diminished its engineering resilience, and the system might change its regime, i.e., find a new stable state, the magnitude of disturbance needed for the system to switch regime is called ecological resilience (Keersmaecker et al., 2017). Assessment of such changes in vegetation response is of major importance for management purposes. It may provide a warning for increased vulnerability and may serve as an indication for land managers that additional attention is required. Consequently, if changes in vegetation response are not observed and considered in ecosystem monitoring, important information about vegetation stability may remain unnoticed with severe consequences for production and function (Keersmaecker et al, 2017).

There are a number of changing conditions and factors which are expected to and have already been recorded to impact on native vegetation throughout the North East Victorian region. Some of these factors are reviewed in detail below.

Changing temperatures

In the future, the climate is projected to be warmer and drier (NECMA, 2016). This in turn will have impacts on the vegetation communities of North East Victoria. Current projections indicate that normal days may be 0.7– 1.9°C hotter than now on average and night temperatures will be warmer by about 0.9°C for the period of 2020-2039 (DELWP, 2021). This change amplifies for the period of 2040-2059 with projections for normal days may be 1.3–3.1°C hotter than now, especially during summer months and night temperatures will be about 1.6°C warmer (DELWP, 2021).

Many vegetation communities have the ability to withstand temperature extremes for short periods, however when these periods are extended it subjects the vegetation to increased stress. Currently the average number of days per year over 35°C for Shepparton is 14.8 and may increase to 22 and for Wodonga is 20.5 and may increase to 30 for the period of 2020-2039 (DELWP, 2021). Average number of days per year over 35°C may increase to 30 for Shepparton and 44 for Wodonga, doubling the number of hot days currently for the period of 2040-2059 (DELWP, 2021).

An increase in temperatures will impact vegetation communities through an increase in evaporation. Increased temperatures generally result in hotter and drier conditions, with increased frequency and intensity of extreme events: fire, flood, heatwaves and drought (NECMA, 2016).

Unfortunately, managing the impacts of changing temperatures is generally difficult to achieve. However, one example of how to minimise the effect of increased temperatures (and evaporation) would be to promote the growth of multi layered vegetation structures with particular species selected for canopy cover that will assist with maintaining cooler surface temperatures and protecting shaded vegetation.

Changing water availability

Water is a precious resource which flows through our region's forested catchments, with our region providing about 50 per cent of the inflows into the Murray-Darling Basin system (DELWP, 2021). Changes in rainfall is one of the hardest changes to measure. Victoria may have 20 per cent less rainfall annually with the greatest changes in rain predicted to be in spring across the period of 2020-2039 and an increase in the frequency of summer storms predicted (DELWP, 2021). The predictions of less rainfall will result in a dryer climate, increasing the frequency of hotter (extreme) days (DELWP, 2021). While the long-term climate trend in the region is for reduced average rainfall, there may be more intense rainfall events leading to an increase in the frequency and severity of floods (NECMA, 2016; NECMA 2022). Clouds can hold more rain at higher temperatures which results in heavier downpours being more likely, but less rain overall and for rainfall may be more scattered and less predictable (DELWP, 2021). Rainfall has already declined more over the last two

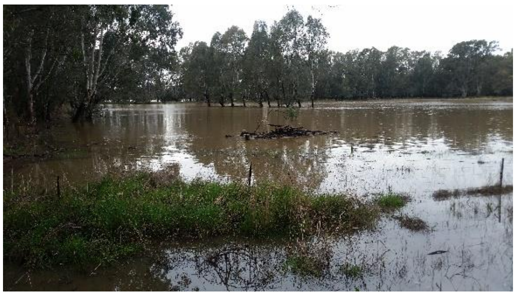

Figure 2- Increased flooding due to large rainfall events expected. Photo of flooded paddock near Wangaratta, Sophie Enders

decades than anticipated and is projected to become more variable due to complex land and atmosphere conditions (DELWP, 2021).

Natural hydrological cycles within a catchment are influenced primarily by rainfall (DELWP, 2021). It is estimated that climate change impacts will lead to a decline in annual average and winter rainfall reducing average streamflow in the North East catchment by as much as 25% to 45% by 2050 and inflows to the Murray basin by up to 40% by 2070 (NECMA, 2022). A drying climate will place increased pressure on waterways, floodplains and wetlands already under stress (NECMA, 2022).

The effect of water drawdown should also be considered in its affects on vegetation species (Froend & Sommer, 2010). Froend & Sommer (2010) found that under lower rates of water table drawdown (9 cm $year^{-1}$), a progressive change in floristic composition was observed over a 33-year period. The abundance of species with a preference for wetter sites was significantly reduced, whereas that of more drought-tolerant species increased. Furthermore, those communities which rely on seasonal flooding will be affected by a reduced winter rainfall (DELWP, 2022), which will result in a reduce run-off and collection. Wetlands are one example which with reduced regular flows of water and flooding may see a shift towards dryland vegetation (DELWP, 2022).

Distribution of species shift

Although the landscape and vegetation communities in North East Victoria are relatively diverse and therefore more inherently resilient to climate change, the risk to biodiversity in the North East region is not uniform, and many species and communities are particularly vulnerable to rising temperatures and changes to fire regimes (NECMA, 2022). Over time, we will see some species disappear from certain places and be replaced by others (including weeds and pests) which will cause a new landscape structure to emerge (DELWP, 2022). The distribution of species will shift, with some sensitive ecosystems likely to shrink or disappear. This may result in the loss of native species, while more tolerant species and ecosystems may expand, which may result in a greater composition of weedy species (DELWP, 2022). These shifts may result in a loss of dominant species and a loss in ability to provide certain ecosystem functions such as providing habitat (DELWP, 2022)

Warmer and drier conditions can impact on species and ecological communities unable to adapt fast enough to the rate of climate change (NECMA, 2016). Characteristics associated with increased climate vulnerability of communities and species include being in poor condition due to existing stresses, for example edge effects from vegetation clearing, having highly restricted distribution or climatic tolerance, small population sizes (often associated with low genetic variability and capacity to adapt), low reproductive output, poor dispersal capacity, and reliance on continuous habitat for migration and dispersal (Victorian Government, 2013). Species reliant on patches of native vegetation that are small and isolated are particularly at risk where surrounding land uses present a barrier to migration to more suitable climates (NECMA, 2016). Possible impacts from climate change include changes in the dominant species and structure of existing vegetation types, decline or loss of local populations of species, and species extinctions (NECMA, 2016; NECMA, 2022). Changing climate conditions may also change the threat of invasive species with the ability of exotic species to become more or less invasive (NECMA, 2016).

Possible impacts from climate change include changes in the dominant species and structure of existing vegetation types, decline or loss of local populations of species, and species extinctions (Steffen et al., 2009). In the North East, a south easterly shift in suitable climates will push species towards the Alps and into higher elevations. Mountainous regions will act as a refuge for nearby lowland species but will not act as refuge for the species that currently rely on cool upland habitat (Reside et al., 2013). Climate refuges provide cooler, moister or more stable conditions to which species can retreat during extreme events such as droughts, heatwaves or fires and are critical to the survival of species and regional biodiversity (NECMA, 2022). Alpine environments are extremely vulnerable to climate change as these areas are already confined to the highest altitudes of the Australian Alps and climate models project a decline in maximum snow depth and duration of snow cover (Bhend et al., 2012). Projected changes indicate that a contraction of the alpine environment may occur (NECMA, 2016). Warming of alpine environments has the counter-intuitive effect of increasing cold-exposure for species such as the Mountain Pygmy Possum, which rely on a blanket of snow cover for warmth during hibernation (NECMA, 2016). The cooler climate of the Victorian Alps has been identified as a key climate refuge for the Australian continent (Reside et al., 2013).

The view that plants will fail to move around the landscape at the same rate as climatic change (Davis, 1989; Roberts, 1989; Huntley, 1991) clearly indicates, at least for predicting ecosystem and vegetation change, that the major processes for investigation of future climate influences are migration and regeneration. Those attempting to predict migration rates of propagules will be forced to consider human influences (Woodward, 1992). In some ecosystems, interaction and feedback among drivers (inputs or influences which cause change) can produce traps that confine an ecosystem to a particular state or condition and influence processes like succession, increased fire frequency; climate changes may cause such shifts (Lindenmayer et al., 2022).

Large scale canopy dieback in native forests has been increasing across landscapes which is likely to result in a landscape with fewer trees (DELWP, 2022). This has been influenced by a variety of factors including fire frequency and severity. Snow gums due to increased risk from beetles are one such species that has been recorded as dying out, within increased fire frequency contributing to this population decline (DELWP, 2022).

Figure 3- Increased risk of pest species such as the Fleabane pictured here post fire, Photo Swamps, Rivers & Ranges

Pest species/ competition and disease

Increased heat and decreased water availability have altered the composition of forests and the spread and impact of pathogens, disease and pest species (DELWP, 2022). Secondary to the Snow gum example discussed earlier, an example is the expected spread of Phytophthora owing to wetter summers and warmer winters (DELWP, 2022). The spread of Myrtle rust is also increased in these climate conditions. Changing temperature, wind and rainfall patterns along with more extreme weather events will likely affect how weeds and pests spread, but it can be difficult to predict which species will benefit (DELWP, 2022).

Fire and weather events

From 1980 to 2015, 91 per cent of the recorded 15,700 natural disasters in Australia were weather related (DELWP 2020). Climate change is projected to increase risks such as longer and more extreme heatwaves, doubling of hot days (above 35 degrees) and severe storms and floods (Victorian Climate Projections 19). The Hume region has a long history of large and intense fires, some involving significant loss of life and property (DELWP, 2021). Major fire events in the region include a total of 1.27 million hectares burnt in the 1939 Black Friday fires, more than 503,000 hectares in the 2003 Alpine fires, 444,000 hectares in the 2006/07 Great Divide fires, 247,000 hectares in the Black Saturday fires (2009), 36,000 hectares in the Harrietville fire (2013) and 320,120 hectares in the 2019/20 Black Summer fires (DELWP, 2021). Hence large areas of the landscape have been burnt in relatively recent timelines. Ecosystems at risk of fire have already been affected by stressors such as habitat loss, invasive species and bushfire will be impacted in differing degrees by climate change, even within the same ecosystem types (DELWP, 2022).


Figure 4- Trees recovering from the 2019/20 Bushfires near Abbeyard, Photo Sophie Enders

The regions bushfire risk is influenced by weather, soil moisture and fuel levels (DELWP, 2021). Under extreme weather conditions it becomes difficult to control and the risk of severe, uncontrollable fires cannot be eliminated (DELWP, 2021). The primary effects of extreme weather events are well known and include loss of life, injury, loss of ecological systems and ongoing damage to land and water resources. But secondary impacts such as damage to roads and transport, infrastructure and personal property, fauna and flora future health, and ongoing community mental health from fires, storms and pandemic events can cause equal or greater challenges (DELWP, 2021).

Limitations

A significant portion of Australia's "food bowl" is sourced from the Hume region. About 45 per cent of our land is used for agriculture (primarily grazing) and about 50 per cent consists of conservation and natural environments (DELWP, 2021). While the majority of impacts on agricultural production in North East Victoria are negative, climate change is likely to reduce the threat of salinity and soil acidification in North East Victoria due to declining aquifer recharge and subsequent lowering of the water table and associated dryland salinity (NECMA, 2022). Whilst the impacts on the agricultural sector are not to be downplayed and many of the aspects that influence the agricultural sector will also impact our natural environments, this article does not review this impact as it is an area of discussion of its own.

There are many aspects of plant physiology and populations which we don't yet fully understand enough to assist us to fully understand how certain communities may respond to climate change. Some of these characteristics may impact the ability of species or ecosystems to survive, grow, disperse and reproduce under changing environmental conditions. Plant physiology, how plants function, including temperature tolerance is likely to leave some species vulnerable to climate change (DELWP, 2022). The demography and population parameters are likely to be affected by whether plants are able to survive to reproductive age and contribute to the overall population numbers (DELWP, 2022). Genetics can provide information on how a particular individual species may be able to tolerate future climatic conditions, those species will higher genetic diversity may have a better resilience to change (DELWP, 2022).

Opportunities

The North East is diverse and has inbuilt resilience to climate change, but continued action at a local level, planning around vegetation and soil, habitat fragmentation, and pest plants and animals is required. To allow people to make decisions about climate change adaptation and mitigation, there is a need for ongoing knowledge exchange (NECMA, 2016). Climate change knowledge is complex and diverse. Knowledge exchange or sharing between and among various stakeholders – including researchers, policy makers, practitioners and communities – plays an important role in developing effective climate change policies, strategies and plans, and encouraging innovation. It enhances the ability of organisations, governments and communities to identify, plan and implement ways to mitigate and adapt to climate change (NECMA, 2016). Climate change presents many challenges and opportunities for natural resource managers, including organisations, community groups and landholders. An effective response involves coordinated research and development across sectors and regions and identification of priority areas for research include modelling, mitigation, and adaptation (NECMA 2016).

New plantings, especially of native species, and the re-establishment of forests and woodlands offer one of easiest ways for land managers to offset greenhouse gas emissions, as the amount of carb on sequestered is measurable and verifiable (NECMA, 2016). The establishment of forest plantations and agroforestry and retention of regrowth (especially environmental plantings of native species) also offers important biodiversity benefits. Stands of vegetation may enhance habitat for wildlife as well as improve connectivity between areas of native vegetation and grasslands (NECMA 2016). Such plantings may also provide opportunities to bolster vegetation species at risk through reduced population numbers. Well planned and strategic plantings also have the ability to provide refugia, seed sources for native vegetation species and extreme event refuges for fauna. There is considerable potential to utilise existing data sourced from herbaria collections and field naturalists' notes and diaries to identify native plant species suitable as biological indicators of climate change (Rumpff, Coates & Morgan, 2010).

The Climate Watch Program is a collaboration between the Bureau of Meteorology, Melbourne University and Earth watch to understand how shifts in rainfall and temperature are impacting our natural systems. Trial sites across Australia have established monitoring and tracking projects, collecting information on changes to plant flowering times, life and breeding cycles and migration (DELWP, 2021). The trials are the first of their kind in the southern hemisphere and information is collected through citizen science students and adults who are invited to participate (DELWP, 2021). Collaborations such as this are important in landscape scale management and intervention.

There may be potential opportunities and learnings that can be taken from the agricultural sector and potentially applied to those species at significant risk of extinction due to climate change. One such example could be breeding programs though understanding these come with substantial cost and ethical considerations. To remain viable, breeding programs need first to maintain the adaptation of a species to a region (Chapman et al., 2012). If climate change becomes sufficiently severe to cause a species to no longer be grown in a region, then breeding would be no longer helpful for that area. The decisions that need to be made in breeding programs in the face of climate change are: (*1*) will the plant species remain viable in a given region, and (*2*) how can the plant species be adapted to continue to provide an economically desirable yield and quality (Champan et al., 2012).

Conclusion

The management, monitoring and preservation of native vegetation species throughout the North East Victorian region requires an educated, considered and collaborative approach. Management actions should be adaptive and informed by purposefully collected rigorous scientific data. The combination of efforts from scientific, research, agency and community organisations and individuals will be key in achieving landscape scale outcomes. Whilst there are many factors which will beyond the control of local communities, early action through multi-factor approaches will give our vegetation communities the best chance of survival. At the same time, we may need to accept changes in the vegetation.

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References

Bhend J, Bathols J, & Hennessy K 2012, Climate change impacts on snow in Victoria. Australian Centre for Australia Weather and Climate Research

Chapman, S., Chakraborty, S., Dreccer, M., & Howden, S. (2012) *Plant adaptation to climate change – opportunities and priorities in breeding*. Crop and Pasture science. 63(3) 251-268. https://doi.org/10.10710CP11303

Department of Environment, Land, Water and Planning (2021, November). Hume Regional climate change adaptation strategy. The State of Victoria Department of Environment, Land, Water and Planning

Department of Environment, Land, Water and Planning (2022). Natural environment climate change adaptation action plan 2022-2026. https://www.environment.vic.gov.au/natural-environment-adaptation-action-plan/climate-change-impacts

Froend, R., & Sommer, B. (2010) Phreatophytic vegetation response to climatic and abstraction-induced groundwater drawdown: examples of long-term spatial and temporal variability in community response. *Ecological engineering*, 36(9), 119-1200

Keersmarcker, W. Lhermitte, S., Hill, M., Tits, L., Coppin, P., & Somers, B. (2017) Assessment of regional vegetation response to climate anomalies: a case study for Australia using GIMMS NDVI time series between 1982 and 2006. Remote Sens. 9(1), 34. https://doi.org/10.3390/rs9010034

Lindenmayer, D., Bowd, E., Taylor, C., & Likens, G. (2022) The interactions among fire, logging and climate change have sprung a landscape trap in Victoria's montane ash forests. *Plant Ecology*, 223, 733-749.

North East Catchment Management Authority. (2022). *Our region*. North East Catchment Management Authority. https://www.necma.vic.gov.au/About-Us/Our-Region

North East Catchment Management Authority. (2016). *North East Climate ready NRM strategy*. North East Catchment Management Authority.

Reside A, VanDerWal J, Phillips B, Shoo L, Rosauer D, Anderson B, Welbergen JA, Moritz C, Ferrier S, Harwood T, Williams K, Mackey B, Hugh S, Williams Y & Williams S 2013, Climate change refugia for terrestrial biodiversity: Defining areas that promote species persistence and ecosystem resilience in the face of global climate change, National Climate Change Adaptation Research Facility

Rumpff, L., Coates, F., & Morgan, J. (2010) Biological indicators of climate change: evidence for long-term flowering records of plants along the Victorian coast, Australia. Australian journal of Botany. 58(6) 428-439. https://doi.org/10.1071/BT10053

Steffen W, Burbidge AA, Hughes L, Kitching R, Lindenmeyer D, Musgrave W, Stafford Smith M & Werner PA 2009, Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's biodiversity to climate change, CSIRO Publishing, Australia Stokes C & Howden M 2010, Adapting agriculture to climate change: Preparing Australian agriculture, forestry and fisheries for the future, CSIRO Publishing, Australia

Woodward, F. Tanslet Review No. 41 Predicting plant responses to global environmental change. New Phytol. 122, 239-251

Victorian Government 2013, Victorian Climate Change Adaptation Plan, Victorian Government, Melbourne