MURRAY BASIN
NRM CLUSTER

CLIMATE CHANGE IN AUSTRALIA
IMPACTS & ADAPTATION INFORMATION FOR AUSTRALIA'S NRM REGIONS

Climate-ready Restoration

Guidelines for identifying restoration priorities to support biodiversity conservation under a changing climate

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We recommend using these guidelines to inform 'Step 5: Design interventions to maintain values' in The NRM Adaptation Planning Framework: six steps to transform NRM planning under global change (Ryan et al. 2016)

1. Introduction

Climate change in the Murray Basin NRM Cluster is likely to impact on our environment in many ways. How these changes are likely to influence biodiversity are briefly outlined in the "Climate change and biodiversity in the Murray Basin NRM Cluster region – how will it affect your region?" fact sheet (https://www.terranova.org.au/repository/murray-basin-nrm-collection/climate-change-and-biodiversity-in-the-murray-basin-nrm-cluster-region-2013-how-will-it-affect-your-region). Some of the more important climate predictions for the near future (i.e. by 2030) for The Murray basin NRM Cluster that are likely to influence how we undertake restoration include:

- higher temperatures
- hotter and more frequent hot days and fewer frosts
- less rainfall in the cool season but no changes for the warm season
- an increase in heavy rainfall events and more time in drought
- a decrease in humidity over winter and spring
- increased evaporation rates and reduced soil moisture (Timbal *et al.* 2015).

Of course, these directional changes to climate are not impacting on biodiversity in isolation of other drivers. Historic and future land-use (including vegetation clearance), pest plants and animals, inappropriate fire regimes, and water diversions for human use are but some of the important drivers that impact on native biodiversity at regional levels, and these can act on biodiversity in ways that are not completely independent of climate change. The purpose of this document is to provide advice on the interpretation of biodiversity and climate change information, to inform strategic decisions regarding restoration activity, and hereby improving the chance that restoration activity will contribute to landscape conservation under future climates. This advice complements "Restoration Sub-project Component 2", whereby the aim is to provide planners and land managers with advice on how to adapt their current restoration practice to climate change, in the context of the strategic planning advice provided here.

This document has three broad elements:

1. A broad framework for identifying where restoration is likely to contribute to biodiversity conservation under future climates, and under what circumstances climate change will have a strong influence on the nature of his restoration;
2. The application of this framework, at a landscape scale, to the landscapes of the MDB Cluster NRM Regions, with advice on how to interpret this analysis for the delivery of practical restoration programs.
3. What do we do with this information? Next steps.

2. Why Do Restoration?

Ecological restoration is undertaken by NRM for a wide variety of reasons:

- soil management and restoration
- water quality improvement
- maintain/improve agricultural sustainability
- amenity/sense of place
- increase local biodiversity
- support conservation of regional biodiversity (Kimber et al., 1999)

Opportunities often exist to meet multiple objectives, both in terms of strategic planning and on-ground delivery and design. Across all of these reasons, there is a need for developing clear objectives for restoration, such that success can be measured against these objectives. This is particularly important for restoration that is aimed at supporting regional biodiversity conservation, given the complex nature of biodiversity (Gibbons, 2010, Hobbs, 2007).

2.1 When to intervene (or, what would happen if we didn't?)

Where restoration is being considered as a tool in the conservation of regional biodiversity, a key step in planning is to identify which elements of biodiversity require restoration activity in order to prevent irreversible, undesirable change (e.g. extinction, or ecosystem collapse). Key questions to ask might include:

- What are the different elements of biodiversity of interest?
- What is their current state, and in what direction are they trending?
- What is the risk of irrecoverable loss, if nothing is done?

In many cases in southern Australia, the effects of historic impacts (such as broad-scale vegetation clearance) on native biodiversity may have already played out (e.g. the impacts on biodiversity have already led to local extinction). Identifying those elements of biodiversity that continue to decline, versus those for which the effects have already been felt, is thus an important step in describing where restoration may be useful to prevent biodiversity loss (Figure 1).

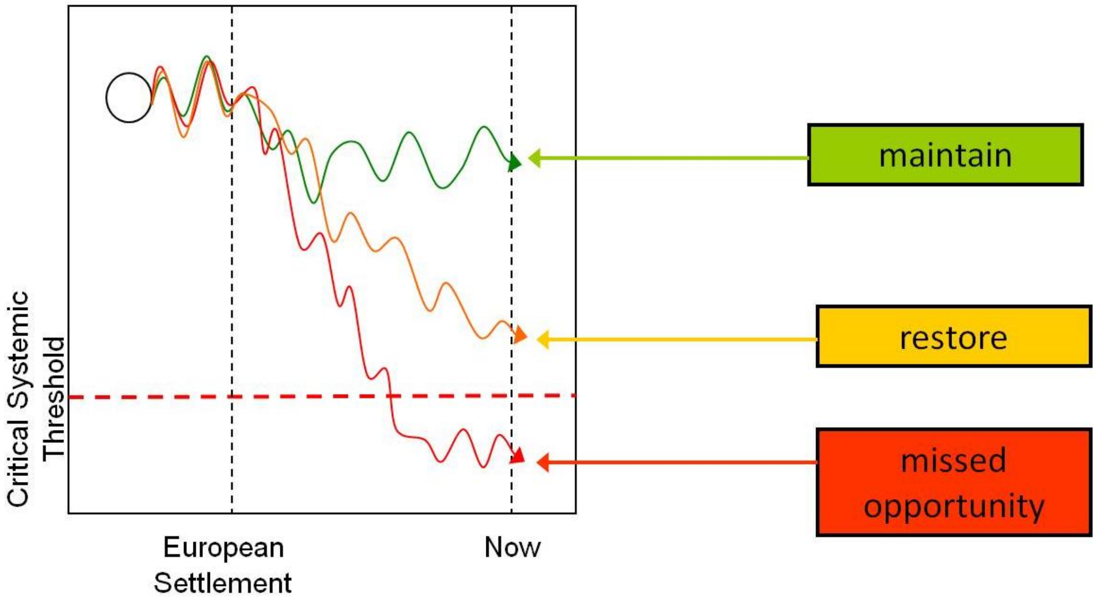


Figure 1. Conceptual diagram of three alternative state and trends for biodiversity. *This conceptual framework describes the biota of landscapes in terms of alternative stable states, with critical thresholds that, once crossed, are difficult to reverse (e.g. local extinction). Our broad management response will then depend on the state and trend of a landscape's biota: where extant biodiversity are relatively stable (even if they are different from the pre-European composition), our key strategy may be maintenance; this differs from those landscapes that have undergone significant historic change, but whose biota have stabilised in response to these changes (e.g. extinctions have already happened). Under this framework, restoration should focus on those elements that still contain biota of interest (extant native species), but that are likely to lose those biota if no intervention is undertaken (orange line above).*

Ideally, these questions would be answered using multiple lines of evidence, including patterns of landscape change and responses of biodiversity (e.g. species) to this change through time. These lines of evidence can potentially be drawn from different sources, including quantitative (spatial and non-spatial) and expert-driven models. As a minimum, we might use simple landscape metrics such as habitat remnancy to inform the relative risk of collapse to different landscapes and ecosystems. However, some analyses have also used declines among species with common habitat requirements as additional evidence of risk (Rogers et al. 2012).

If landscapes, ecosystems or species are identified as being at risk in a region, we then need to ask if restoration is the most appropriate intervention to mitigate this risk. This will depend strongly on what is driving decline in those elements we are concerned about: if decline is being driven by (for example) ongoing predation by introduced carnivores, then restoration is unlikely to stabilise or reverse these declines. So, given that we have identified elements of biodiversity that are a risk in our region, a second set of questions to ask might be:

- What are the drivers of decline?
- Will the effect of these drivers be mitigated by restoration activity?

The case study presented for the southern Yorke Peninsula landscape of South Australia (Figure 2) provides an example of how different elements of biodiversity in a landscape would benefit (or not) from restoration, by looking at this series of questions (Rogers 2011). In this case, the different ecosystems in the landscape were identified, and the state and trend of each ecosystem was determined using multiple lines of evidence (landscape history, along with changes in distribution of ecosystem-dependent fauna).

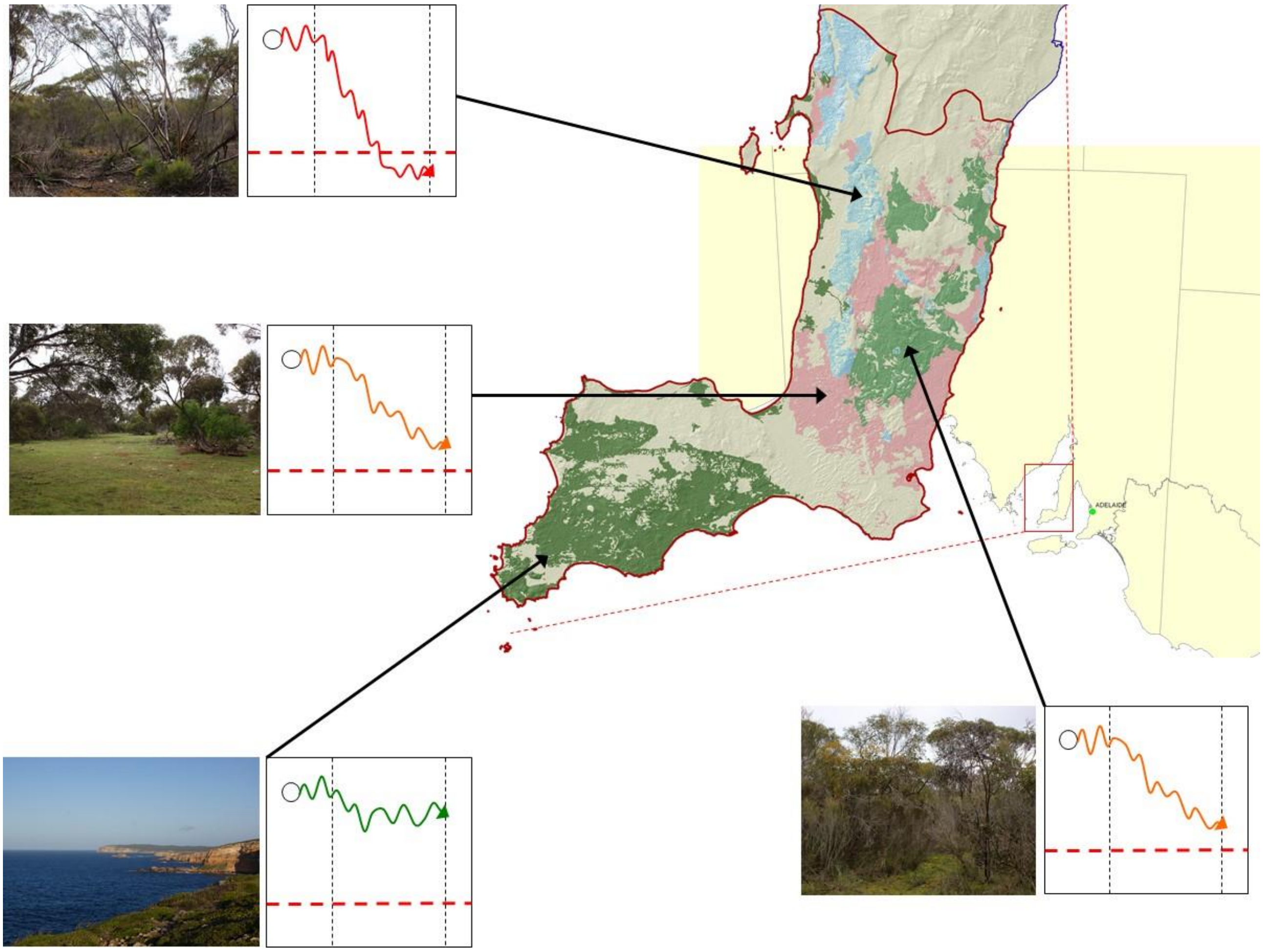


Figure 2. Application of Landscape Assessment Framework to the Southern Yorke Peninsula Landscape of southern South Australia. *In this example, four broad ecosystems were identified, and their state and trend estimated from a combination of land-use history, history of development, and the state and trend of bird species that are strongly associated with the different systems. This analysis clearly identified a need to focus intervention on two of these four ecosystems (open grassy woodlands on calcrete – middle left, and mallee shrublands on aeolian sand – bottom right), while two ecosystems were not prioritised for intervention (coastal mallee on shallow calcrete soils – bottom right, and mallee woodlands on deep calcareous soils – top left). After Rogers (2011).*

2.2 But what of climate change?

The guidelines provided above focus on the impact of historic drivers on biodiversity, and how an understanding of these drivers and their impact can inform where restoration can support conservation. Climate change places an additional stress on the biodiversity of these landscapes that has the potential to modify our management response, or even our objectives with regard to conservation outcomes. In some instances, the best way to respond to this additional stress will be to improve the resilience of these systems to cope with change (by responding the questions asked above), under the assumption that highly resilient ecosystems will have the capacity to adapt to this change. However, for many landscapes the impact of future climates will be so great that a more appropriate (but also potentially more risky, given the uncertainty) management response may be to facilitate transformation, encouraging transition to ecosystems that, while novel when compared to historic systems, have the potential to still retain some desirable functions. In these cases, revegetation will rely less on understanding the historic distribution of plant species and ecological communities, and more on what mix of species are likely to persevere in the future, and still provide those functions.

Given the significance that the impact of climate change will have on biodiversity, we need to find some way of planning our restoration programs, in such a way that they account for both the major non-climate impacts (and the state and trend of the biota) described above, and climate change, as well as how climate change interacts with these drivers. So in addition to the questions above, we need to ask an additional question that relates specifically to climate change:

- To what extent are the biota of interest sensitive to changes in climate?

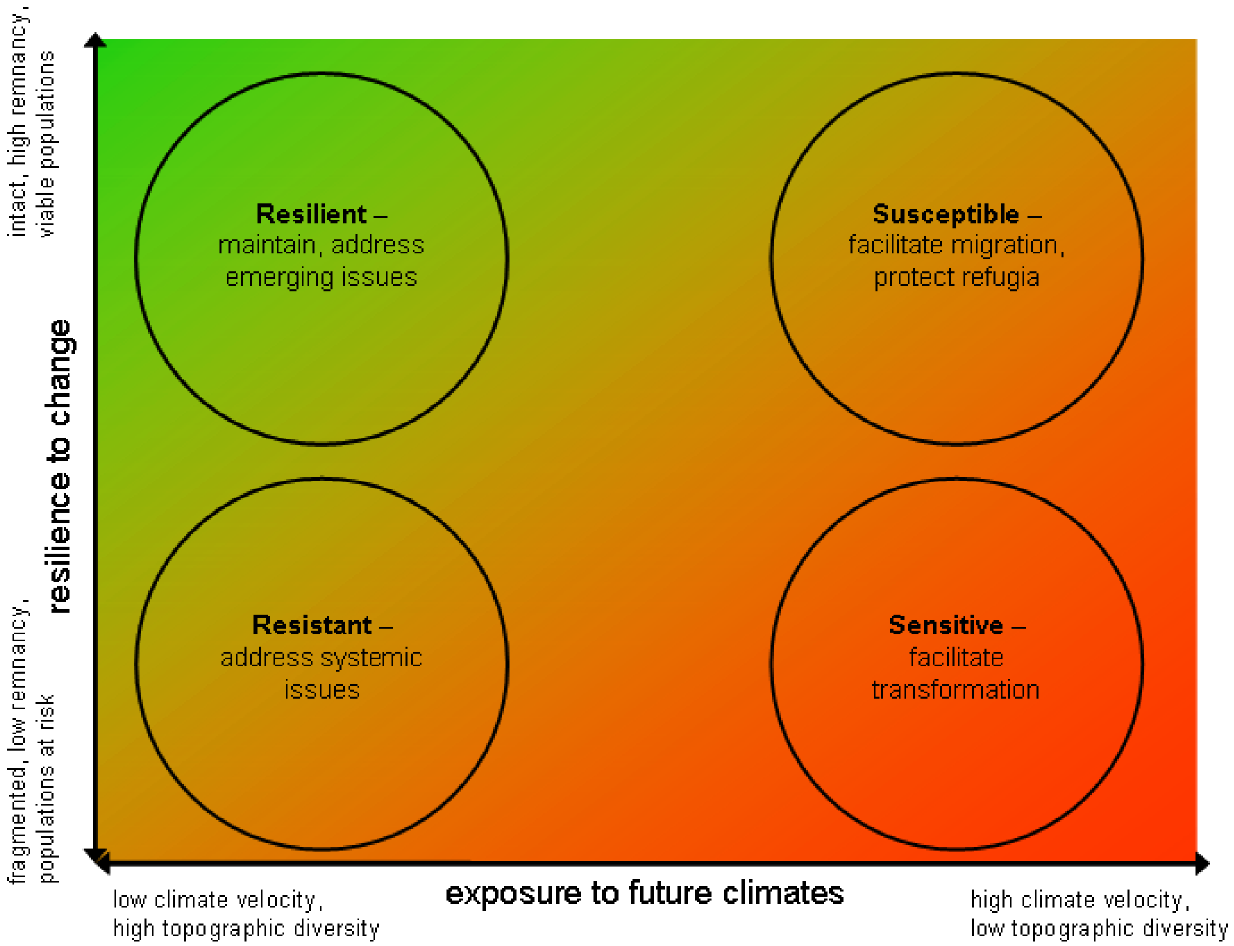


Figure 3. Conceptual framework that links exposure of landscapes to future climates, landscape resilience to change, and broad management responses. For any element of biodiversity, the relative impact of climate change – and the most appropriate management response – can be described by two 'axes of concern': the relative sensitivity of the biota to changing climate, and the resilience (or adaptive capacity) of biota to cope with change. See text for further explanation on how to interpret this framework. After Gillson et al. (2013).

The impact of climate change on biodiversity thus depends on a combination of two key features:

1. Climate Sensitivity. The nature and extent of changes in the climate that are relevant to biodiversity in the landscape of interest. While directional climate is likely to be universal, the extent and nature of change will depend on regional geographic features (e.g. latitude, proximity to oceans) and local features (e.g. topographic variation) that will impact on the relative exposure of biodiversity to these changes.

2. Resilience to Change. The capacity of a landscape's biodiversity to respond to change (generally), and climate change (in particular). A system's resilience is often referred to as adaptive capacity; highly resilient systems are more likely to cope with certain amounts of change (and thereby maintain their structure, function and composition), while systems whose resilience has already been eroded may shift to alternative states under even moderate levels of climate change.

While landscapes will fall on a continuum in this two dimensional space, it is possible to classify these landscapes into one of four broad categories that provide some guidance on how a landscape's biota may respond to directional climate change, and where restoration may be required to achieve desirable conservation outcomes (Figure 3; Gillson et al. 2013; Rogers 2013):

Resilient Landscapes (low exposure + high resilience). Resilient landscapes are relatively intact, with functional ecological processes operating and adequate redundancy in response and function. They are also less likely to be exposed to large changes in relevant climate parameters (as they are found, for example, in topographically diverse areas). Our response for these landscapes is largely passive: we should aim to maintain the existing structure, function and composition of these systems, and ensure that emerging threats (such as novel invasive species or socio-economic drivers) are identified and their effects mitigated.

Resistant Landscapes (low exposure + low resilience). While resistant landscapes are less likely to be exposed to large changes in climate, their resilience has already been compromised by other drivers (e.g. habitat destruction, inappropriate grazing regimes, inappropriate fire regimes or unsustainable extraction of water resources). These landscapes thus have low capacity to cope with shocks, and are likely to lose native biodiversity irrespective of the nature of future climates. Our adaptation responses for these systems are to identify the key drivers (such as those listed above) that are placing these systems at risk, and implement active management to address the impacts of these drivers. In many agricultural landscapes, the key intervention in these landscapes is likely to include habitat restoration (including revegetation) where historic vegetation communities may continue to be useful templates for restoration.

Susceptible Landscapes (high exposure + high resilience). While susceptible landscapes are relatively intact, they are also relatively exposed to large changes in climate. The biota of these landscapes are likely to have the capacity to respond to climatic shifts, such as through dispersal and migration to suitable environments, or through increased capacity for *in situ* adaptation. In cases where opportunities for migration or refuge do not exist (e.g. if appropriate climate-edaphic settings no longer occur, or are unavailable due to other land-uses), our adaptation response may be similar to that for sensitive systems. However, in many cases our response may be to support these adaptive responses, such as through increasing connectivity, or buffering areas of habitat for external shocks. Carefully planned revegetation may be an important contributor to these management responses, although historic vegetation communities may not necessarily be appropriate in all cases even where revegetation is a useful response.

Sensitive Landscapes (high exposure + low resilience). The resilience of sensitive landscapes has already been compromised by human impacts, and their capacity to cope with change is already compromised, and this risk of biodiversity loss is already high. Furthermore, these systems are exposed to changes in climate. Because these systems are already compromised, they may not have the capacity to track changes in the distribution of suitable physical environments. The risk to these systems is that their composition changes in the future, such that they function in a way that is undesirable. In these landscapes, the most appropriate management response may be to facilitate the transformation of these systems to ones that, while novel in their structure and composition, retain desirable ecological functions (Hobbs et al. 2006, 2011). For example, if habitats for threatened species are likely to change, how can we facilitate this change such that the functional habitat attributes for these species be retained in the landscape (Lin & Petersen 2013). A key step in these cases is to identify what these desirable functions are how do we want future ecosystems to function, and why (Hobbs et al. 2011)? The role of restoration (and revegetation) in these cases should be carefully considered, both from the perspective of setting objectives of biodiversity conservation, and from the perspective of restoration design (given that historic vegetation communities will be poor templates for future activity, and the focus may shift from composition to function).

3. Application of this Framework: The Subregions of the Murray Cluster

For the purposes of this analysis, we have applied the framework described above to the broad landscapes (defined here as the IBRA Subregional boundaries) of the Murray Cluster NRM regions. The IBRA Subregions reflect broad biogeographic areas with relatively consistent biophysical attributes (relative to differences among subregion). As a result, the range of climatic (and, therefore, relative exposure to directional climate change) and edaphic environments are likely to be internally consistent relative to the differences between Subregions. Furthermore, at a coarse scale the broad range of land use and other drivers that are strong determinants of resilience are likely to have some relative consistency within these subregions (again, relative to inter-subregional to resilience).

For the purposes of this application, we have answered the questions posed above using two key pieces of information:

Sensitivity to future climates: The sensitivity of a landscape's native biodiversity were assessed using a summary of the predicted vascular plant species turnover developed for the Biodiversity Implications module of Adapt NRM (http://adaptnrm.csiro.au/biodiversity-impacts/). This model describes the predicted difference in vascular plant community composition at each point in space, between now and 2050, under an RCP 8.5 climate scenario (Harwood 2014). The distribution of this climate sensitivity score across the Murray Basin subregions is presented in Figure 5. For each IBRA subregion, the compositional difference between each pair of points (current v 2050) was averaged across the subregional area to develop an average compositional dissimilarity (called climate sensitivity in Figure 6).

Resilience to cope with change: Landscape resilience was calculated here using the Condition Score model developed across the East Coast, Central Slopes and Murray Basin NRM Cluster Regions (Drielsma et al. 2014). The distribution of this landscape resilience score across the Murray Basin subregions is presented in Figure 4. For this analysis, the metric we used to determine resilience was the proportion of a subregion's area that had a condition score of >50. This threshold score approximates the threshold for mapped native vegetation in broadacre agricultural landscapes; however in this case it also discriminates highly degraded native vegetation in pastoral areas (where the condition score can be <50).

There are limitations to the use of these datasets for this purpose, not least of which is the subregional scale at which they are being applied. However, this analysis provides a coarse assessment as to which landscapes managers should begin to think about their adaptation strategy with regard to biodiversity conservation, and, in particular, where restoration activity is likely to contribute to biodiversity conservation in the future, where it isn’t, and (even in cases where there is a good reason to undertake restoration), where historic paradigms of vegetation are likely to become less and less relevant. Importantly, these metrics of climate sensitivity and resilience are an reasonably sensible example of the type of metrics that could be used at the landscape scale; obviously if one were to apply the frameworks described here to other levels of biodiversity (e.g. ecosystem or species) than other metrics would need to be considered.

It is also important to point out that, in this case, we have applied a single set of climate predictions to determine the likely response of biodiversity to climate change at the landscape scale. As with the scale at which we have chosen to apply this framework, ultimately the framework should be applied using multiple, plausible climate scenarios and estimates of resilience.

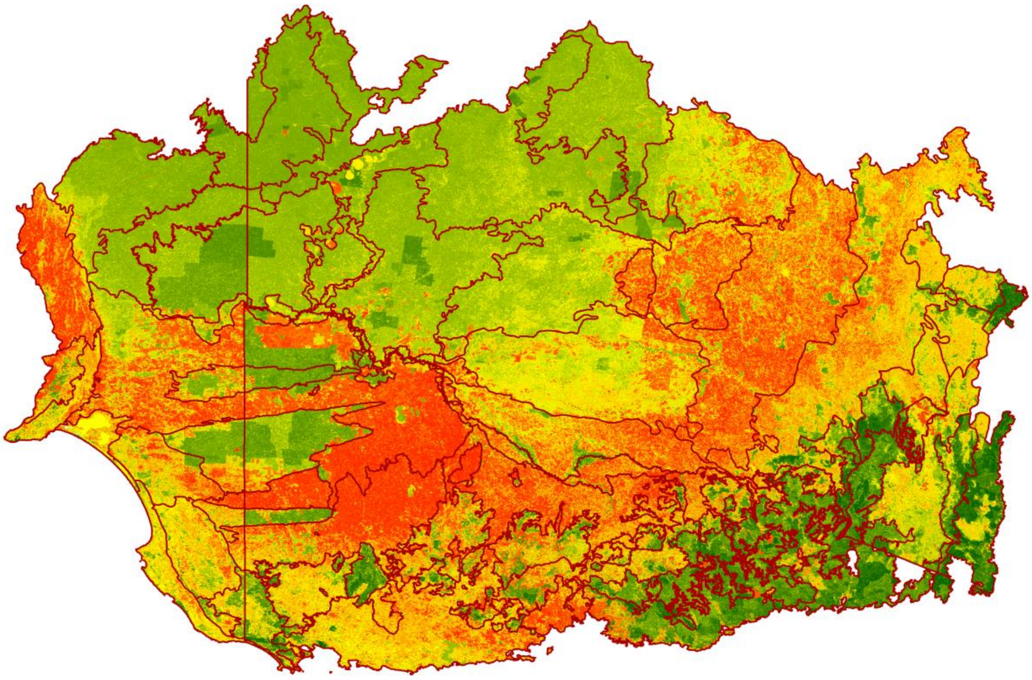


Figure 4. Scaled condition of native vegetation across the IBRA subregions of the Murray cluster. The Condition Score presented ranges from 0.1 (red) to 95 (green). See text for further detail.

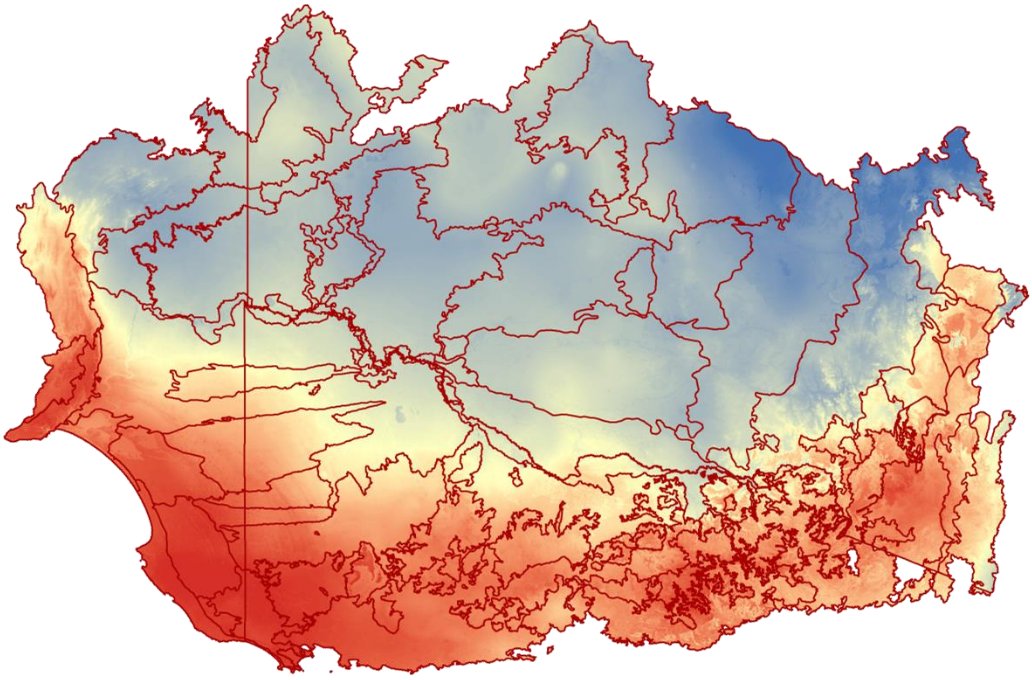


Figure 5. Predicted climate sensitivity for the Murray Basin IBRA subregions. The predicted compositional difference in vascular plant species between 2010 and 2050 under an RCP 8.5 climate scenario was used as a proxy for climate sensitivity. This climate sensitivity metric ranges from 0.17 (red) to 0.6 (blue). See text for further details.

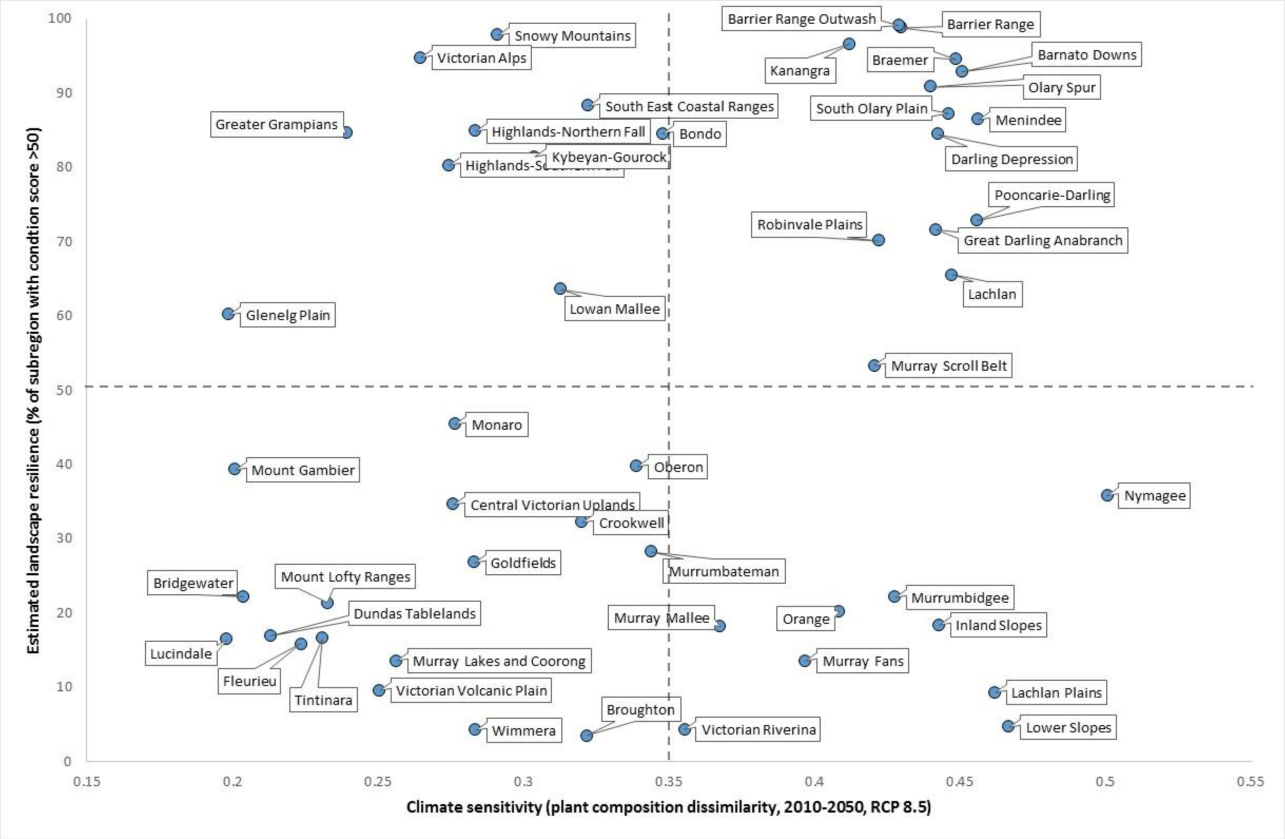


Figure 6 Distribution of subregions with regard to Climate Exposure (x axis) and landscape resilience (y-axis). Climate Exposure refers to the average compositional dissimilarity between the current flora, and the predicted flora under a future climate scenario. Estimated landscape resilience refers to the proportion of the landscape's area with a condition score of >50. Condition scores were generated by the 3C project; climate exposure data were generated by the Adapt NRM Module 'Implications for Biodiversity' (http://adaptnrm.csiro.au/biodiversity-impacts/).

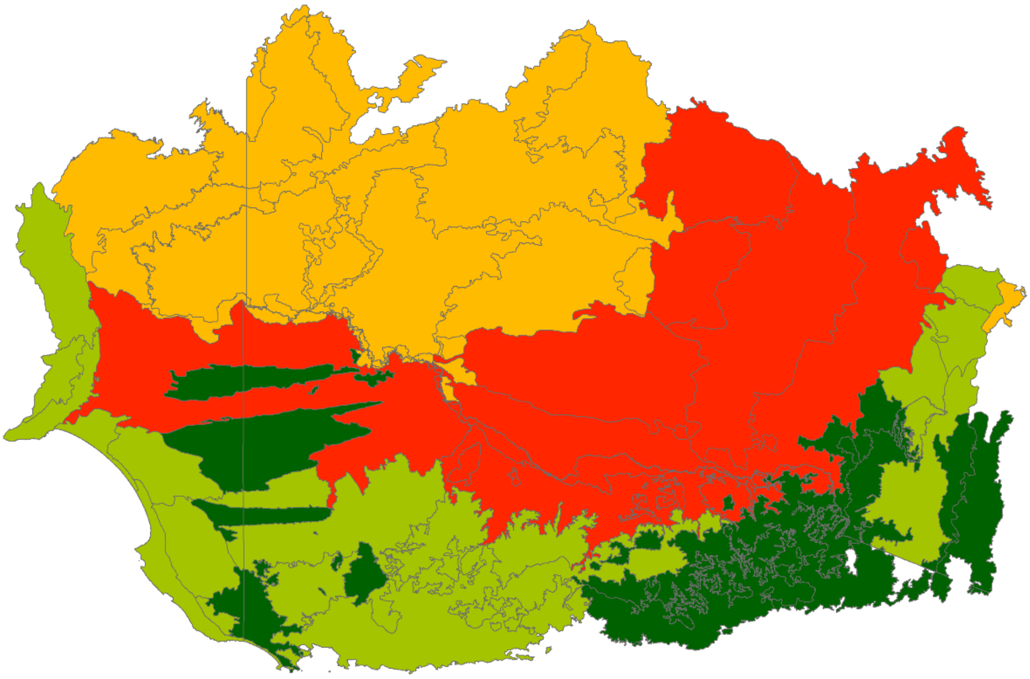


Figure 7. Map of Murray Basin Cluster IBRA Subregions, colour-coded to one of four categories that relate to the four broad categories outlined in Figure 3. Dark Green: Resilient; Pale Green: Resistant; Orange: Susceptible; Red: Sensitive. See text for implications of this map for the application of restoration/revegetation activity.

4. Where To Next: Considerations for Applying This Framework For Decision Making

The information presented here provides some evidence of where restoration activity is likely contribute to the conservation of a region's biodiversity, and recommendations regarding the broad objectives of this restoration activity (accounting for each landscape's exposure to future climates, and ecological resilience to this change). Of course, the recommendations provided here need to be placed in the context of other reasons for undertaking restoration (such as those listed above), and we should consider the impact (positive and negative) of undertaking restoration to meet different objectives have on our ability to meet the ecological requirements of declining biodiversity. Importantly, this information can also be used to inform discussions with regional communities regarding their aspirations for the landscapes within which they live.

The landscape-scale analyses presented here can also be used in conjunction with other spatial analyses that have been developed through the Murray Basin Cluster program. For example, the 3C modelling, upon which some of this analysis is based, provide spatial recommendations regarding priority locations for revegetation, using a combination of likely responses to climate change and general ecological principles (e.g. connectivity and fragmentation). For landscapes where the application of this framework recommends some form of restoration (e.g. Resistant and Susceptible landscapes), this finer scale spatial information can provide some guidance as to the best places to undertake this restoration activity. However, for those landscapes for which traditional forms of restoration are less likely to contribute to the conservation of biodiversity, more careful consideration of how we use these finer-scale spatial products will be needed. In those landscapes where transformative strategies may be required, a re-setting of our conservation objectives may be required (more focused on functional, for example, than historic paradigms), and the spatial recommendations provided should be used in the context of these new objectives.

The coarse analyses presented here have presented information to inform restoration priorities, at one level of biodiversity (landscape). Our justification for presenting these results at the coarse level of landscape is that we assume that, at this scale, the interactions between climate change and other systemic drivers are relatively consistent, particular in relation to the nature of these interactions in other (including neighbouring) landscapes, and, in many cases, represents the scale at which management strategies are likely to be relevant. For example, the inherent nature and drivers of environmental change (that we may wish to address) are relatively consistent within the eastern Mt Lofty Ranges (comprised of lower rainfall erosional slopes that support open grassy ecosystems), and so it seems reasonable to develop conservation objectives across that scale. However it would not makes sense to also apply the same plans to the adjacent western murray mallee, that has very different inherent properties (a matrix of deep depositional soils and shallow calcrete that support mallee and shrubland communities). Of course, landscape-scale conservation objectives are only one set of objectives, and we also need to ensure that other levels of biological organisation are considered in our conservation plans (see below).

Furthermore, the climate sensitivity of the different landscapes presented here is based on a single set of climate information (see Section 3). There is, of course, a level of uncertainty with regard to what the future climate will look like. For the purposes of this landscape-level analysis, the impact of alternative climate scenarios is likely to be low, as the final analysis essentially presents a relative level of risk. However, it may pay in the future to apply this framework in a way that accounts for a range of plausible futures.

Of course, similar types information can be applied to the frameworks above, for other levels of biodiversity, such as ecosystems, species and populations (Keith et al. 2008; Prober et al. 2012; Fordham et al. 2013). This will an important consideration when applying the landscape-level information provided here, as a resilient landscape (for example) may still contain ecosystems and/or species that are sensitive to climate change. For example, the Victorian Alps and Snowy Mountains landscapes are considered to be relatively resilient to climate change (Figure 6, Figure 7), based on their overall predicted changes in plant composition, and high proportion of intact native vegetation. However, elements of biodiversity within these landscapes, such as Alpine Sphagnum Bogs (at the ecosystem level), and Corroboree Frog *Pseudophryne corroboree* and Mountain Pygmy Possum *Burramys parvus* (at the species level) are likely to be highly sensitive to climate change, due to low resilience, high climate sensitivity or both. The vulnerability of species and ecosystems to climate change – even within landscapes that are considered Resilient – needs to be considered in order to comprehensively assess the vulnerability of biodiversity to climate change within a given region.

5. References

Drielsma, M., G. Manion, J. Love, K. J. Williams, T. Harwood & H. Saremi. 2015. 3C Modelling for Biodiversity under Future Change. Sydney: NSW Government OEH.

Fordham, D. A., H. R. Akçakaya, B. W. Brook, A. Rodríguez, P. C. Alves, E. Civantos, M. Triviño, M. J. Watts, and M. B. Araújo. 2013. Adapted conservation measures are required to save the Iberian lynx in a changing climate. Nature Climate Change **3**:899–903. Available from http://www.nature.com/doifinder/10.1038/nclimate1954.

Gibbons, P. 2010. Prioritising conservation in temperate woodlands. *In*: Lindenmayer, D., Bennett, A. & Hobbs, R. J. (eds.) Temperate Woodland Conservation and Management. Collingwood Victoria: CSIRO Publishing.

Gillson, L., T. P. Dawson, S. Jack, and M. a. McGeoch. 2013. Accommodating climate change contingencies in conservation strategy. Trends in Ecology and Evolution **28**:135–142. Elsevier Ltd. Available from http://dx.doi.org/10.1016/j.tree.2012.10.008.

Harwood, T. 2014. 9-second gridded continental biodiversity analyses for Australia : November 2014 Short summary. CSIRO, Australia. Available from http://doi.org/10.4225/08/5487E15A42EB6.

Hobbs, R. J., Higgs, E. & Harris, J. A. 2006. Novel ecosystems: Theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography **15**:1–7.

Hobbs, R. J. 2007. Goals, Targets and Priorities for Landscape-Scale Restoration. *In:* Lindenmayer, D. B. & Hobbs, R. J. (eds.) Managing and Designing Landscapes for Conservation. Oxford, UK: Blackwell Publishing Ltd.

Hobbs, R. J., L. M. Hallett, P. R. Ehrlich, and H. A. Mooney. 2011. Intervention Ecology: Applying Ecological Science in the Twenty-first Century. BioScience **61**:442–450.

Keith, D. a, H. R. Akçakaya, W. Thuiller, G. F. Midgley, R. G. Pearson, S. J. Phillips, H. M. Regan, M. B. Araújo, and T. G. Rebelo. 2008. Predicting extinction risks under climate change: coupling stochastic population models with dynamic bioclimatic habitat models. Biology Letters **4**:560–563.

Kimber, S. L., Bennett, A. F. & Ryan, P. A. 1999. Revegetation and Wildlife. What do we know about revegetation and wildlife conservation in Australia? School of Ecology and Environment, Deakin University.

Lin, B. B., and B. Petersen. 2013. Resilience, regime shifts, and guided transition under climate change: Examining the practical difficulties of managing continually changing systems. Ecology and Society **18**.

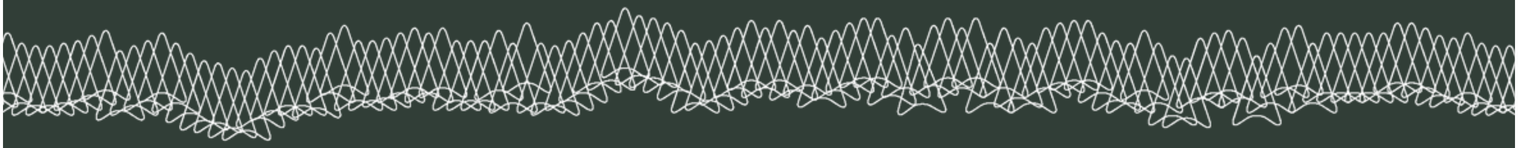
Prober, S. M. et al. 2012. Facilitating adaptation of biodiversity to climate change: A conceptual framework applied to the world's largest Mediterranean-climate woodland. Climatic Change **110**:227–248.

Rogers, D. J. 2011. A Landscape Assessment for the Southern Yorke Peninsula Landscape of the Northern & Yorke NRM region. Department of Environment, Water and Natural Resources, Adelaide, SA.

Rogers, D. J. 2013. A framework for nature conservation under future climates , to inform climate adaptation planning in the Adelaide & Mt Lofty Ranges NRM region. Department of Environment, Water and Natural Resources, Adelaide, SA.

Rogers, D. J., N. Willoughby, P. Pisanu, A. McIlwee, and J. Gates. 2012. Landscape Assessment : A Process for Identifying Ecosystem Priorities for Nature Conservation. Adelaide, SA.

Ryan, P., Doerr, V., Doerr, E., Dunlop, M. & Gorddard R. (2016) The NRM Adaptation Planning Framework: six steps to transform NRM planning under global change. CSIRO, Australia and the Australian Resilience Centre, Beechworth.



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