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Q1

First name

Callum

Q2

Last name

Bryant

Q3

Email

[redacted]

Q4

Can we contact you about your submission (if needed)?

Yes

Q5

Can we add your email to our mailing list for occasional updates on this topic?

Yes

Q6

What best describes you?

I am a researcher/academic.

Q7

What best describes your main regional interest?

Statewide NSW

Q8

Your submission may be published. If you do not want your personal details or responses published, please tell us here.

I agree to have my submission published with my name.

Q9

What do you consider is the most significant action(s) we can undertake to protect and restore biodiversity and ecosystem function on private lands?

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Dear Review Committee,

Please find below our comments for consideration in the NRC Review of options for restoring nature and enhancing value for landholders, and the 'NSW plan for nature NSW
Government response to the reviews of the Biodiversity Conservation Act 2016 and
the native vegetation provisions of the Local Land Services Act 2013' (NSW Plan for Nature).

The review has requested comments that apply strictly to private land; however, it is not possible to consider restoration and improvement of environmental values in isolation of the broader context of changing climates, which is not tenure specific. Reshuffling and loss of species' climatic distributions presents a recognised, continent-wide threat to all listed and unlisted native species and community assemblages, and their derived ecosystem services. Actions taken on regional/ private land must be considered within a broader climate mitigation and adaptation strategy
that spans tenure. While restoration and improvement of condition is the primary focus of the revisions and recommendations, our responses are primarily focused on actions to mitigate and adapt against loss of condition. In particular, recommendations here focus primarily on the need for improved preparedness, improved responsiveness and improved adaptability in our approaches, all of which are necessary in a novel risk environment. We also suggest many specific emerging tools and actions for priority, and make specific comments on risks and opportunities on private land.

NOVEL RISK ENVIRONMENT
While the regulatory frameworks across these tenures differ and the stakeholders, incentives and resourcing available differ on both private and public land, the natural environment on both is primarily at the mercy of novel risks associated with changing climates (Figure 1) that operate across all of these conditions. Novel emergent risks include:

(1) Rapid rates of decline in condition value (days-years)
- Heat wave and drought dieback (Nolan et al. 2020; Losso et al. 2022; Choat et al. 2024; Hislop et al. 2023).
- Insect outbreaks that destroy vegetation (Pureswaran, Roques, and Battisti 2018; Bryant et al. 2024; Seaton et al. 2015).
- Fire frequencies and severities (Hislop et al. 2023; Fairman, Nitschke, and Bennett 2016; Morgan, Shackleton, and Walker 2024)
- Storm damage and windthrow (Hinko-Najera et al. 2024).
- Legacy effects of compound disturbances (Matusick et al. 2018; Kannenberg, Schwalm, and Anderegg 2020; Choat et al. 2024).

(2) Large magnitude/ extent of impacts to environmental values;
- Unprecedented scales and severities of impact (Hislop et al. 2023).

(3) Prolonged periods of discontinuity of valuable ecosystem services
- Iterative disturbances delaying recovery (Matusick et al. 2018; Kannenberg, Schwalm, and Anderegg 2020; Choat et al. 2024).
- Slow growing species such as trees taking decades to centuries to re-establish mature forms (Morgan, Shackleton, and Walker 2024).
- Limited dispersal such that local species impacted may be poorly suited to the changing disturbance regimes, and other better suited native species may have natural dispersal limits.

(4) Irreversible ecosystem state transitions and loss of function.
- Transition from forest to woodland or shrubland(Morgan, Shackleton, and Walker 2024; Bassett et al. 2024).
- Erosion or pollution that permanently alters an ecosystem's productivity (Ge et al. 2025)
- Local loss of composition due to climate maladaptation (S. M. Prober et al. 2012; Ordonez, Williams, and Svenning 2016; Lavorel and Garnier 2002).

(5) These risks may be further compounded by ineffective adjustment of environmental management in response to these novel risks
- Poor risk identification and mitigation.
- Delayed responses leading to missing key stabilisation windows (Bassett et al. 2024).
- Ineffectual responses.

Figure 1. A graphical illustration of the novel risk environment for nature and legislated natural values across tenures. A) A hypothetical spread of possible unmitigated climate-driven impact scenarios for any given locality: best-case (dotted line), intermediate (solid line) and worst-case (dashed line). B) Novel risks associated with climate impacts include 1) rate, 2) magnitude, 3) discontinuity, 4) irreversibility. C) Illustration of broad aims of management interventions to mitigate risks through actions to resist/ delay declines and direct/ assist restoration.

DEGRADED VEGETATION TRENDS
Already we are witnessing signs of loss of condition and ecosystem change, impacts that are not tenure specific. Background mortality rates in vegetation are increasing across the globe. (Zhang et al. 2014; Carnicer et al. 2011; Mantgem et al. 2009; Peng et al. 2011; Brienen et al. 2015; Lu et al. 2024). Acute mortality events are also increasing (Hartmann et al. 2018; Allen et al. 2010; Allen, Breshears, and McDowell 2015; Trumbore, Brando, and Hartmann 2015). There are many local examples of unprecedented large-scale mortality ecosystem impacts and compositional change that span tenures (Ross and Brack 2015; Bryant et al. 2024; Cowood, Lynch, and Botha 2018; Seaton et al. 2015; Lu et al. 2024; Hislop et al. 2023; Losso et al. 2022; Matusick and Fontaine 2020; Morgan, Shackleton, and Walker 2024; Fitzgerald 2024; Bok et al. 2024; Siclari et al. 2024; Sekaran et al. 2024; Nicholson et al. 2024; Choat et al. 2024; Bentze et al. 2024; Nolan et al. 2021).

It is no longer possible to discern vegetation mortality and dieback events from climate sensitivity and the associated climate-driven refiltering of species' local distributions. Under climate change, these vegetation declines are entirely expected. Climate change is (and will continue to) simultaneously and asymmetrically modify factors that have shaped existing local native vegetation, i.e., abiotic factors (temperature and precipitation regimes), biotic factors (competition, herbivore and pathogen pressure), and temporal factors (disturbance frequencies and severities; (Keith 2004; Matusick and Fontaine 2020). With persistent climate-forcing, significant turnover of local community composition and changes in structure are entirely expected; yet specific futures for complex systems are difficult to model and highly sensitive to unknown interactions. For some systems, climate succession may result in subtle shifts in composition or structure; for other ecosystems, it may result in irreversible ecosystem state transitions.

Depending on the local severity of impacts, these risks may continue to drive significant loss of condition on private and public lands. Predicted vegetation trends include:

(1) Large-scale transformation - Marginally distributed species or specialists or ecosystems (i.e. subalpine woodlands or mountain ash forests (IPCC 2022)) may be more immediately vulnerable, and some communities may have a greater disturbance resilience than others. However, with the magnitude of temperature change predicted, climate change will likely refilter and challenge all communities in all locations. Therefore, we ought to anticipate dynamic behaviour (degradation or transformation) across all estates (Losso et al. 2022; Bassett et al. 2024; Allen, Breshears, and McDowell 2015; Morgan, Shackleton, and Walker 2024).

(2) Sudden and gradual change in condition - Both ongoing background change and unexpected large-scale disturbances are expected following novel extreme events (Lu et al. 2024).

(3) Lagging mortality events following from iterative or compound stressors - These legacy effects are expected to have long-term and sometimes irreversible impacts(Matusick et al. 2018; Anderegg et al. 2013; Kannenberg, Schwalm, and Anderegg 2020).

(4) Increased fragmentation of existing populations - This will cause refiltering of existing native species in protected landscape positions (i.e. by aspect, fire history, height from water table (Keppel et al. 2024))

(5) Declining local native diversity and increased fragmentation of existing forests - Refiltering can only act on the existing species' gene pools and so will therefore reduce native species diversity. New species may arrive, however, without intervention, and these are likely to be those with greater dispersal capacity and an affinity for disturbance (i.e., increased colonisers and weed species)(Grime 2001).

(6) Shortening of living vegetation stature - Tall trees are more hydraulically vulnerable and less likely to re-establish under higher disturbance frequencies. This is expected to convert land to shrubland or mallee forms of woodland (Morgan, Shackleton, and Walker 2024; Nathan G. McDowell and Allen 2015; Fairman, Nitschke, and Bennett 2016).

(7) Unprecedented insect and disease outbreaks - Changing climate conditions act on plants and their consumers differently. Drought stress can tax plants' defence capabilities while amplifying conditions favouring pest species thus leading to runaway outbreaks of pest populations. Furthermore, pest species distributions may expand into naive communities. Numerous examples of large-scale insect blooms have been documented following disturbance (Pureswaran, Roques, and Battisti 2018).

(8) Demographic skews toward younger cohorts - Growth forms that require specific disturbance frequencies to develop will decline in the landscape, i.e. mature woodland trees can take 50+ years form, mature snowgum woodlands up to 100 years. Demographic skews are already being observed in snowgum and mountain ash forests (Morgan, Shackleton, and Walker 2024; Fairman, Nitschke, and Bennett 2016).

(9) Refiltering of existing communities based on differences in traits associated with resilience to threatening disturbance - For example, in a system threatened by greater fire frequencies, co-occurring epicormic resprouters may persist/ expand in occurrence while obligate reseeders may be lost (Clarke et al. 2013; Collins 2020); in systems threatened by drought species with greater resistance to loss of hydraulic function will be retained(Anderegg et al. 2016; Nolan et al. 2021).

(10) Community assembly changes - While spatial richness in species increases with latitudinal increases in temperature (Westoby

et al. 2024), in the short term, without intervention, climate-driven refiltering can only act on the existing local species pools. Therefore we expect a decline in locally adapted native specialists, and persistent arrival of colonists that are fast growing, mobile and disturbance tolerant.

(11) New communities with no historical analogues - It is highly anticipated that, as distributions shift, there will be gradual fragmentation and drift of existing Plant Community Types (PCTs), and an increase in new, ”no analogue” communities. This is expected to lead to poor representation/ loss of species with narrow/ specific distribution requirements (Williams and Jackson 2007) .

Q10

How can we further improve soil, water and vegetation management to protect and restore biodiversity while delivering sustainable economic outcomes?

INVALID, 'UNSTATED' ASSUMPTIONS WITHIN ENVIRONMENTAL REGULATORY INSTRUMENTS:
Community assemblages (on public or private land) are no longer “relatively stable” entities, with risks arising primarily from clearing and development. Instead, they are ecosystems adrift, with multiple potential futures, some more desirable than others. This invalidates several unstated assumptions underlying much of our private and public environmental regulation and restoration infrastructure (Gorddard et al. 2016; S. M. Prober et al. 2017). In particular, assumptions are:

(1) Stationarity - that biodiversity and ecosystem functions/ values are relatively stable, and will therefore improve in condition if we cease clearing, and offset development, and restore to pre-existing communities.
(2) Alignment of ecological values - that biodiversity and ecosystem functional values are relatively aligned and, therefore, that if we protect local species/ localities, secondary ecosystem services will naturally follow.. A particular example is the expected degradation of local species compositional values due to climate re-filtering. This is a severe but difficult to mitigate risk: vegetation structural integrity and ecosystem services (habitat quality, nutrient cycling, soil conservation) may be immediately impacted, but local historic composition may be unaligned with the restoration of vegetation structural and functional integrity. In this case, restoration would require assisted colonisation of climate-adjusted species rather than simple protection.

MITIGATION AND ADAPTATION
Navigating climate succession, despite unprecedented uncertainty, will require an evolution of our management of private and public lands, by adapting or revising the existing regulatory environment. The novel challenge involves mitigating risk to existing priority biodiversity values, while also mitigating emergent risks associated with novel degrees of vegetation instability. While some outcomes are beyond our control, using targeted values-based risk mitigation we can aim to reduce the likelihood and severity of impacts on our values. Timely and informed management responses are constrained by interactions between rules (i.e. legislation, regulation and local management plans, tenure), values (i.e. legislated protections on individual and typified native community assemblages, secondary landscape-scale ecosystem services, cultural and economic priorities) and knowledge (i.e. confidence in our understanding of interactions among ecological components, predictions of possible futures, and the effectiveness of interventions) (Gorddard et al. 2016; S. M. Prober et al. 2017).
Emerging strategies/ actions to expand this response space include:

(IMPROVED PREPAREDNESS:)
(1) Public education regarding the expected realities of climate succession and vegetation dieback.
Iterative stakeholder engagement to prepare and plan for multiple possible futures for a given locality ranging from best-case to worst-case scenarios.

(2) Regulatory revisions to articulate cascading priority environmental assets and values under worst-case scenarios. Many management plans for public and private reserves do not acknowledge the high likelihood of vegetation condition decline caused by climate-driven change. This implicitly assumes the changes will be minor and the required adjustments minimal. In instances where this is not the case, where impacts are catastrophic and triage is required, there is limited guidance and support for reprioritizing of the values of the vegetation/ecosystem.

(3) Dieback and climate-succession value-specific risk assessment/ protection plans require . articulation and identification of hierarchies of values, and hierarchies of control for specific values, and articulation of condition thresholds triggering the cascading of management priorities.
Resilience inventories should aim to:
Map adaptive and neutral genetic variation within species and across populations to inform seed sourcing by identifying resilient genotypes and conserve evolutionary potential (Nicotra et al. 2016; Aitken et al. 2008; Aitken, Jordan, and Tumas 2024)

(4) Characterise variation in resilience to known stressors among/ within species (Nate G. McDowell et al. 2022);

(5) Exploit restoration programs to begin ongoing field trials that explore establishment success of climate-adjusted provenances within species, and future species (i.e. those suited to possible future conditions) (Westoby 2022; L. Broadhurst et al. 2017).

(6) Ongoing prediction and trials of future species using, distribution, bioclimatic and genotypic models (Aitken, Jordan, and Tumas 2024; Bragg et al. 2015; Supple et al. 2018; Nicotra et al. 2016, 22).

(7) Conserving evolutionary potential - Given that we are expecting range contractions for many species, we are at risk of losing rare or regional genotypes. By surveying and mapping the neutral and rare genetic variation across foundation species' distributions, we can make sure rare forms are represented in offsite-plantations dedicated to seed protection and protected from stressors, referred to as seed production areas(Aitken, Jordan, and Tumas 2024).

(8) Securing seed supply for restoration (seed banks and libraries) and resolving seed quality (adapted and adaptable) to guide informed restoration (L. M. Broadhurst et al. 2008; Bragg et al. 2022; Nevill et al. 2016).

(9) Improved temporal and spatial monitoring (condition, structure, composition, recruitment and mortality) via ground-truthing of remote-sensed data with census and disturbance data (International Tree Mortality Network 2024).

(10) Adopting climate-adaptive management decision frameworks to allow improved decision making during and after disturbance events. Many management plans are relatively static documents, however, climate pressures will require timely responses to mitigate irreversible degradation of values where possible (Lynch et al. 2022; 2021; Schuurman et al. 2022; Thompson et al. 2021; Norman and Pegler 2024; Bergstrom et al. 2021; Alexandra 2024; Clifford, Cravens, and Knapp 2022; Peterson St-Laurent et al. 2021; Gorddard et al. 2016; S. M. Prober et al. 2019).

(IMPROVED RESPONSIVENESS:)
(11) Rapid response assessments following disturbance events to assess whether stabilising actions are necessary, whether transitions are likely, the degree to which condition has changed and thus whether condition thresholds have been crossed (Bassett et al. 2024).

(12) Identifying natural refugia following disturbances for priority protection (Keppel et al. 2024)

(IMPROVED ADAPTABILITY:)
(13) Iterative revision of management plans and goals (across public and private tenures) to include expected ecosystem vegetation instability and condition assessments, and assess management intervention effectiveness (Lynch et al. 2022).

(14) Trialing of climate-adaptive/ resilience-motivated management interventions to improve resilience of existing ecosystems and to maintain landscape-level ecosystem function in larger extent ecosystems (these could be ecological thinning, and altered burn regimes; Ruthrof et al. 2024; Baker et al. 2024; DBCA WA Government 2024; Baker et al. 2024).

(15) Ongoing trialing of novel restoration strategies such as fortification, climate-adjusted provenancing or future forest translocation trials, etc (Breed et al. 2013; L. Broadhurst et al. 2017; Supple et al. 2018; Aitken et al. 2008; Twardek et al. 2023; S. Prober et al. 2015; Aitken and Bemmels 2016; Zarew, Bryant, and Nicotra 2024).

Figure 2. Graphical illustration of the three proposed complementary operational and regulatory adjustments necessary to mitigate and minimise loss of condition: (1) PREPARE: Dieback and Climate-Succession Risk Assessment, (2) RESPOND: Dieback, Damage and Recovery Impact Assessment, (3) ADAPT: Resist-Accept-Direct (type) climate-adaptive management decision cycle.

Q11

What do you consider is the most effective way to further support and enable landholders to deliver sustainable land management and production outcomes?

Private tenure as an asset for trialing novel interventions
While it will always be of highest priority to protect and preserve existing intact vegetation and ecosystems where they persist, private land and degraded land are also critically important in the conservation process because they are the primary arena for restoration and revegetation and afforestation for habitat, and because they are most likely to be incentivised by economic drivers such as the nature repair and carbon markets. However, these efforts when taken to restore solely toward reference ecological communities, i.e. the plant-community types historically appropriate for the area (Standards Reference Group SERA 2021), are at risk of being poorly suited to future climates. We cannot fully predict which selection pressures will be applied under future climates due to the lack of resolution around specific climate scenarios and carbon release mitigation, and the complexity of interactions among ecosystem components. Instead, we can model species future distributions with a variety of tools under a variety of scenarios. Therefore, there is a need for ongoing field trials of climate-adjusted provenances for existing species to validate predictions and answer persistent questions: are there variants of existing species that are more suited to future stressors? Are non-local native species - potentially more suited to future conditions - able to be established now (L. Broadhurst et al. 2017; Twardek et al. 2023))? We can use degraded landscapes to trial responses and interventions that might later be needed to stabilise currently intact neighbouring ecosystems. While current appetite for interventions is low in high quality intact ecosystems, this appetite will be dynamic in response to changing degrees of degradation, at which point proven stabilising actions will be needed. Private/ degraded landscapes are opportunities to trial novel restoration interventions (L. Broadhurst et al. 2017) to enable informed responses under worst- case scenarios (Cravens et al. 2024).

Private tenure vulnerable to limited disturbance response resourcing
State environment departments and national parks and reserves agencies possess greater staff and resourcing to facilitate rapid responses teams for high value ecosystems, e.g., the Rapid Response Recovery Team, DEECA, Vic Government, which is dedicated to tactical damage and recovery assessments and then operational and recovery monitoring (Bassett et al. 2024). In private landscapes, this response and resourcing is even less likely. Therefore, the resourcing for vegetation impact responses on private-tenure land requires special consideration, as it will remain a blindspot unless otherwise addressed.

Summary
Notably, many of the points made above are supported by the NSW Plan for Nature. However, the NSW Plan for Nature's focus is on improving and restoring nature, with very little consideration on preparing for worst-case scenario losses of condition due to the entirely expected impacts of climate change. Our primary recommendation, therefore, is to include provision in the legislative framework for environmental disaster planning and triage through cascading prioritisation of environmental values to maintain/ limit irreversible impacts to core environmental values (ecosystem services such as habitat and forage provision, carbon and hydrological cycling, structural diversity, integrity and habitat provision, soil conservation). We also emphasise the emerging need for specialist teams and preparatory development of tools to assess disturbance impacts and guide stabilising actions following disturbances: private tenure land, in particular, is at risk of being overlooked in this regard.

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