ACT Government

Future Fire in the ACT

Report on the Climate Adaptation for Nature initiative case study on the implications of future fire regimes in the ACT

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2024

A Climate Adaptation for Nature initiative case study report

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Contents

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We acknowledge the Traditional Custodians of the ACT, the Ngunnawal people. We recognise the special relationship and connection that Ngunnawal people have with this Country. Ngunnawal people are a thriving community whose life and culture are intrinsically connected to this land in a way that is core to their physical and spiritual wellbeing, their cultural practices, law/lore, songlines, and stories. Ngunnawal people have maintained a tangible and intangible cultural, social, environmental, spiritual and economic connection to these lands and waters for thousands of years.

Executive summary

Climate change is increasingly reshaping our ecosystems and society, with the scale and pace of change expected to accelerate in the coming decades. Climate change is already causing longer, elevated, and more frequent periods of escalated bushfire danger,[1] and fire agencies have experienced unprecedented fire conditions with massively destructive effects.[2] Large bushfires across southeastern Australia, including in the ACT, in recent decades have shown the potential for intense and widespread bushfires to cause significant detrimental impacts on nature, infrastructure, and people. The connection between anthropogenic climate changes and recent bushfires in Australia has been established.[3]

Projections anticipate a future with an increased number of days with extreme heat and elevated fire danger, extended periods of drought and more frequent and intense weather events, and an increase in average temperature of up to 4.5°C and a decrease in average rainfall of up to 25% by 2090.[4] These changes would significantly increase the likelihood of fire[5] in the landscape, with impacts being amplified by interdependencies between fire risks and other shocks and stressors. These changes pose far-reaching and unprecedented challenges for decision-making and planning.

The Climate Adaptation for Nature (CAfN) initiative is being led by the Office of Nature Conservation (ONC) in the Environment, Planning and Sustainable Development Directorate (EPSDD) with support from the Commonwealth Scientific and Industrial Research Organisation (CSIRO). It is testing approaches to sectoral adaptation planning through case studies and aims to help build thinking and capacity in the broader ACT Government. This report captures insights from the first CAfN case study, a climate-ready analysis of the increasing likelihood of fire in the

[1] Jones et al., Climate change increases the risk of wildfires. *ScienceBrief Review.* (2020). Accesed at: https://ueaeprints.uea.ac.uk/id/eprint/77982.
[2] Vallient, John. Fire Weather: A true story from a hotter world. Alfed A Knopf, Penguin Random House LLC, New York, 2023.
[3] van Oldenborgh, G. J., Krikken, F., Lewis, S., Leach, N. J., Lehner, F., Saunders, K. R., van Weele, M., Haustein, K., Li, S., Wallom, D., Sparrow, S., Arrighi, J., Singh, R. K., van Aalst, M. K., Philip, S. Y., Vautard, R., and Otto, F. E. L. "Attribution of the Australian bushfire risk to anthropogenic climate change." *Nat. Hazards Earth Syst. Sci.*, 21, (2021): 941–960.
[4] Climate Change in Australia. Accessed May 20, 2024: https://www.climatechangeinaustralia.gov.au/en/projections-tools/climate-analogues/analogues-explorer/
[5] In this report, fire is used broadly to refer to fire in the landscape from a combination of prescribed burns, managed bushfires, and uncontrolled bushfires. (See Managed bushfire, Prescribed burn, and Uncontrolled bushfire in the glossary).

landscape. The report outlines adaptation pathways to help the ACT government and community navigate the challenge of living well with changes to fire regimes as a result of climate change.

This analysis is *preliminary,* as the case study was a pilot implementation of the CAfN framework, it was limited in scope and resources, was not comprehensive in its coverage of climate and fire risk-related issues, and participation/consultation was limited to EPSDD staff. The near-term interventions outlined in this report are not recommendations, but outline possible near-term adaptation issues and opportunities that could be considered in further planning.

Methodology and engagement

The case study developed six adaptation pathways for preparing for future changes in fire regimes using a five-phase approach. Experts from across EPSDD, including the Parks and Conservation Service (PCS) Fire Management Unit, ONC, and the EPSDD Traditional Custodian Engagement unit, participated in two workshops and subsequent meetings. CSIRO and EPSDD integrated and synthesised the content. The process included:

Current values and priorities were identified and discussed.

A **greatest plausible change scenario** was developed to help participants anticipate future impacts of climate change on key values (nature, life, and property) facing the ACT Government and community (see Box 1).

Box 1: Greatest plausible change scenario for future fire in the ACT region

For **fire**, the scenario anticipates significant increases in elevated fire weather conditions, lengthening of the bushfire season, more frequent fire, and more frequent impacts of fire on the things that society values (e.g. cultural and ecological assets and the built environment). For **biodiversity,** the scenario anticipates widespread changes due to climate and fire, including altered vegetation structure, redistribution of communities and ecosystem types and turnover of species (loss and gain of species).

Participants explored issues and developed transformational responses under three themes, with one overarching theme. Six **climate-ready objectives** were developed under these themes (see Figures I-VI). For each climate-ready objective, an **adaptation pathway** was developed, as follows.

Future climate-ready policy and management settings were developed to outline a set of long-term actions that would support the climate-ready objectives. These were designed as actions that could be effective in the future. They would primarily be implemented by government in collaboration with business and the community. These future actions are often outside the set of actions that are currently familiar and acceptable.

Future **enabling conditions** were scoped, outlining the values, rules, and knowledge[6] that would need to be in place to support decision-makers in choosing and implementing effective adaptation.

Participants identified **near-term interventions** that could be implemented (primarily by ACT Government, often in partnerships) to contribute to the establishment of the enabling conditions (see Figures I-VI).

[6] The values, rules, and knowledge framework developed by Gorddard et al. (2016) recognises that in general the conditions that promote or hinder climate adaptation fall into the domain of values (e.g. what the public wants), rules (how laws/policies structure or restrict action), or knowledge (e.g. what we know how to do).

Adaptation pathways

Overarching theme: Managing the impacts of changing fire regimes under climate change

This overarching theme and objective captures enabling conditions shared across the climate-ready objectives in the other themes.

Climate-ready objective #1: Minimise the social and environmental impacts of fire in the ACT, while climate change increases the likelihood of bushfire in the landscape

Near-term interventions	Enabling conditions Values (V), Rules (R), Knowledge (K)	Future climate-ready policy and management settings
Engagement with community, fire experts, and government to enhance understanding of future fire risks and trade-offs, and to evolve community attitudes and preferences towards fire management in accordance with future risks and impacts.	Appreciation of future fire risk and associated impacts (V) Collective anticipatory capacity and awareness of cascading consequences (V) Greater understanding of smoke on health and wellbeing, including fire practitioners and community (K) Planning, strategic documents and legislation anticipate and accommodate trajectories of change in climate, ecosystems and fire regimes (R) Cross tenure approach to assessing and managing fire risk (R)	Policies and processes accommodate future fire management conditions and consider long-term climate, environmental and ecological changes in planning. A shared narrative and objectives for the future. Ongoing dialogue among stakeholders about changing fire risk and evolution of the ACT community's relationship with fire. Ongoing evolution of rules and knowledge as fire conditions change. Sustainable workforce (physical effort, smoke, stress). Community wellbeing (smoke, security/relationship with fire and fire risk).
Fill knowledge gaps to understand and reduce smoke impacts on health, considering the anticipated rise in smoke exposure for community and fire management personnel.		
Capacity building, skills and training for government and community to anticipate and swiftly recognize unintended consequences of decisions and actions, and to make informed choices in complex situations.		
Policy and planning to develop tools, processes and scenarios for planners to engage with changing fire regimes and ecosystems, and incorporate this into strategies. Establish policies and processes enabling fire practitioners to test new management strategies. Incentivise long-term planning and collaboration across government sectors to address climate change and emerging risks. Analyse the ACT Bushfire Management Planning Framework and related documents to identify ways they can anticipate and accommodate changes in species and ecosystems; enable adjustments in fire management standards for future fire regimes; create opportunities for increased Ngunnawal management of Country; address heightened smoke impacts on health; and respond to evolving community preferences and risk tolerance across various decision-making levels. Review and update monitoring programs to anticipate changes and distinguish between favourable and unfavourable trends. Develop metrics to evaluate fire management and conservation strategies in the face of significant ecological shifts.		

Figure I. Adaptation pathway for climate-ready objective #1

Theme 1: Landscape-scale fire to maintain a mosaic of different times since fire

Maintaining a mosaic in the landscape of different times since fire, and potentially the season and intensity of the previous fire, is expected to reduce the intensity and spread of fire in extreme conditions and increase the diversity of ecological responses to fire.

Climate-ready objective #2: Reduce the intensity and spread of uncontrolled bushfire through the establishment of an extensive mosaic of times since fire throughout the landscape, while the incidence of fire increases with climate change

Near-term interventions	Enabling conditions Values (V), Rules (R), Knowledge (K)	Future climate-ready policy and management settings
Engagement with community, government and fire management agencies about future fire conditions and landscape mosaics of times since fire, to inform the evolution of preferences, risk appetites and shared understanding of risks and responsibilities.	Community and expert support for more frequent and extensive prescribed burning in the landscape and the use of bushfire to achieve a desired time-since-fire mosaic. (V) Understanding of the ecological impacts of large-scale prescribed burning & knowledge about protecting and maintaining long unburnt areas and other areas with high conservation value. (K) Tools and resources such as fire behaviour forecasting, access, enhanced suppression capabilities. (K) Where appropriate, bushfires are allowed to be managed to contribute to landscape fire objectives, as opposed to being rapidly suppressed. (R) Policy and processes enable more agile prescribed burning, use of Ngunnawal fire practices, and management of bushfire to meet fire management objectives. (R)	Fire regimes are managed to be in equilibrium with climate as it changes, i.e. more frequent fire and shorter fire intervals across the landscape. A program of fire management integrating extensive prescribed burning and the management of bushfire to achieve burning objectives, rather than a default objective of rapid suppression.
Fill knowledge gaps on: the feasibility, outcomes, and ecological implications of fire regimes shifting towards more frequent, less intense fire, and, managing bushfire to meet land management objectives. Develop fire regime models to understand the dynamics and trade-offs under different climate change scenarios.		
Capacity building, skills and training to monitor and predict real-time fire behaviour to guide decision making; to conduct larger prescribed burns; to manage bushfire to meet landscape scale fire management objective.		
Policy and planning to develop metrics for evaluating fire management and conservation outcomes that accommodate significant ecological change. Analyse the social, policy, and legal implications of managing bushfire to meet land management objectives. Identify opportunities and impediments for more agile prescribed burning and enabling Ngunnawal fire practices to contribute to management objectives.		

Figure II: Adaptation pathway for climate-ready objective #2

Theme 2: Stronger protection of built, cultural, and ecological assets from more frequent occurrence of uncontrolled fire

Stronger protection from fire can come from an enhanced system of buffers[7] (Figure III), and enhanced design, construction, and maintenance of buildings and open spaces to increase their ability to resist fire (Figure IV). Special attention may be required to ensure Ngunnawal cultural values are protected from increased fire in the landscape, both planned and unplanned (Figure V).

Climate-ready objective #3: Reduce the likelihood of bushfire affecting valued assets through a system of enhanced buffers, while the incidence of uncontrolled bushfire in the landscape increases

Near-term interventions	Enabling conditions Values (V), Rules (R), Knowledge (K)	Future climate-ready policy and management settings
Engagement with community and landholders, in a place-based way, about future fire risk and the benefits and costs of future enhancement of the buffer system around urban areas (i.e. their management, size and design), to balance aesthetic, recreational, cultural and ecological values with fire risk. Engagement with landholders to increase awareness of 'co-ownership of risk' and shared responsibility.	Widespread support and acceptance for enhanced buffers and their regular maintenance to manage fire risk, around urban areas, that prioritise fire risk reduction while supporting aesthetic, recreation and biodiversity objectives. (V) Community understanding about the benefits and trade-offs associated with different buffer designs and management arrangements. (K) Technical knowledge about buffer designs that are effective in the face of more extreme fire conditions, easy to maintain, resilient, and can be further enhanced over time. (K) Knowledge about maintaining multiple values (aesthetic, recreational, cultural, biodiversity) while managing buffers primarily for fire risk. (K) Dedicated resourcing is available for maintenance and hazard reduction in buffer zones around urban areas and other assets, as the demand changes over time (R) Development codes and regulations include buffers that are designed to be adapted over time. Fire sensitive assets are mapped and prioritised, including built, cultural and ecological assets. (R) Hazard reduction plans are in place for priority assets in the landscape, commensurate with changing fire risk. (R) Shared responsibility across land tenures for managing fire risks. (R)	Enhancing the system of buffers around urban areas and other key built infrastructure so that it is more effective in the face of increased frequency of fire, during more extreme fire conditions. Buffers are readily adapted over time, as necessary, in response to evolving community preferences, improvements in management techniques, and continuing changes in climate and fire risk. Buffers meet multiple objectives (aesthetics, recreation, biodiversity, easy maintenance) while having fire resistance and suppression as the primary consideration. Capacity and resources for effective management of the system of buffers including hazard reduction and fire suppression.
Fill knowledge gaps on modelling and experiments about managing buffers for multiple objectives, such as reducing fire risk; ease of suppression; amenity; biodiversity; ease of management (physical, regulatory, cost); reducing the impacts of smoke from hazard reduction burning; resilience to fire (don't need to be rebuilt); and, reducing ember creation. Modelling of fire behaviour in buffers under different fuel management strategies, as fire conditions become more extreme.		
Capacity building to be more responsive in hazard reduction, including better and finer-scale weather, moisture, and smoke monitoring; in-house capacity for residual risk modelling on annual and seasonal time scales; ability to use hazard reduction burning in buffers opportunistically, where appropriate.		
Policy and planning to identify cultural, ecological and built assets in the landscape that need hazard reduction plans; to implement a cross tenure approach to assessing residual risk from hazard reduction; develop designs for buffers that can be easily enhanced over time; integrate future enhancement of buffers into urban planning and development; establish offsets for the ecological impacts of enhancing buffers. Clarify roles for buffer design, construction and management; built asset standards and maintenance; and, regulation and enforcement of standards.		

Figure III: Adaptation pathway for climate-ready objective #3

[7] Buffer: An area of land on which fuels and other vegetation are managed to provide protection to surrounding lands and assets by reducing the intensity and spread of fire, enabling suppression and reducing the production of embers.

Climate-ready objective #4: Design and maintain buildings and open spaces in the urban environments to resist the impact of fire, while the likelihood of extreme fire weather and uncontrolled bushfire increases

Near-term interventions	Enabling conditions Values (V), Rules (R), Knowledge (K)	Future climate-ready polic and management settings
Engagement with the community about future fire risk in the urban environment to develop a shared narrative about managing multiple objectives. Engagement with community about conforming to, and voluntarily exceeding, new building standards as they are revised in the face of changing fire conditions, and about managing backyards and open space in the context of future fire conditions (i.e. risks, costs, benefits, responsibilities, incentives and enforcement), for example, by combining with existing household information programs, like *Climate-resilient city* and *Climate-wise landscapes* information, or through the *Mingle* program.	Community understanding about the benefits and trade-offs of maintaining fire-resistant urban green space, including in backyards. (K) Balancing of multiple objectives in the urban environment that accommodates the realities of changing climate and future fire risk (e.g. fire resistance, shade, asset protection, Ngunnawal cultural values, aesthetics and biodiversity). (V) Long-term risks and benefits of construction choices are visible in near-term property decisions. (K) Standardised process for assessing and reporting on fire risk rating of existing buildings and open spaces, to inform compliance, insurance, investors, the market, the community and fire planning. (R) Building codes are designed for anticipated future fire conditions rather than contemporary or historic conditions. Process are in place to enable uplifting of existing buildings and open space to new standards. (R) Fire resistance codes for open space including backyards, business and public space to enable design, maintenance, assessment, reporting, compliance and continuous improvement. (R)	Development codes, standards and regulations for suburbs, buildings and open spaces are designed to meet anticipated future fire risk. Fire standards are well understood, transparent and provide effective incentives for exceeding minimum regulated levels. Formal processes are in place for assessing and mandatory disclosure of compliance to standards. Fire standards for open space apply to design and management, and to public and privately managed land. Periodically revised codes and standards are enforced for new *and existing* buildings and open space.
Fill knowledge gaps on long-term societal cost and benefits of implementing enhanced building and open space codes, in new and existing developments, including the costs of not acting, retrofitting costs, insurance costs, loss and suffering, impact on amenity. Research to clarify the residual risk for buildings constructed to different standards in the face of different fire conditions, including future conditions.		
Policy and planning to develop a sliding rating scale for fire standards for buildings and open space, to provide a transparent and robust incentive for increasing the fire resistance of assets (e.g. a scale that relates directly to the reduction in risk from exceeding the minimum design standard for the Bushfire Attack Level (BAL) allocated to a site, and can be interpreted and trusted by prospective purchases, insurers, lenders, etc.).		

Figure IV: Adaptation pathway for climate-ready objective #4

Climate-ready objective #5: Protect Ngunnawal cultural values throughout the landscape, while the incidence of fire increases

Near-term interventions	Enabling conditions Values (V), Rules (R), Knowledge (K)	Future climate-ready policy and management settings
Capacity building and processes in EPSDD to ensure appropriate access to knowledge about Ngunnawal cultural values, including who has access, under what circumstances, what cultural competencies are required, so they can be readily considered in planning and included in datasets, as appropriate.	Widespread appreciation that fire management, and other land management, is on Ngunnawal Country and affects cultural values. (V) Awareness of cultural assets that may need protection from fire. (K) Processes for sharing appropriate levels of Ngunnawal knowledge with non-Ngunnawal fire and land managers. (R) Cultural values are considered in hazard management and incident responses. (R)	*Note: the changes needed for this climate-ready objective need to be determined by a Ngunnawal led process, as only they have the cultural authority to speak and care for cultural values, although all land managers have a responsibility in delivering the objective.*
Policy and planning to develop processes to increase understanding of Ngunnawal values by fire managers. Develop processes to embed a Cultural Values Officer within Incident Management Teams and/or on-ground before and during planned burns and other fuel management operations. Develop processes to embed Ngunnawal values in strategic and operations planning.		

Figure V: Adaptation pathway for climate-ready objective #5

Theme 3: Reawakened[8] Ngunnawal Fire Management

Ngunnawal burning has the potential to play a role in managing landscape fire regimes and maintaining buffers in the ACT and surrounds as the climate changes.

Climate-ready objective #6: Ngunnawal land management is a significant feature of fire management in the ACT and surrounding region, contributing to both Ngunnawal cultural needs and broader societal fire management objectives, while fire regimes and ecosystems change in response to climate change

Near-term interventions	Enabling conditions Values (V), Rules (R), Knowledge (K)	Future climate-ready policy and management settings
Engagement to facilitate yarning, other dialogues and communication between Ngunnawal fire practitioners, land managers and the broader community to build understanding and appreciation of Ngunnawal fire practices and knowledge about Country. Undertake education and dialogues about re-establishing Ngunnawal fire as an integral part of the landscape, including that smoke from Ngunnawal burning is an indicator of an ecological service being provided by Ngunnawal. Engage with Ngunnawal to understand the impediments to access to Country.	Ngunnawal land management knowledge is valued by fire and land management agencies and the broader community. (V) Widespread understanding about Ngunnawal land and fire management practices, including its value to Ngunnawal and Country, and contributions to wider fire and land management objectives. (K) Ngunnawal fire is recognised as an essential part of the landscape and as an ecological service being provided rather than a hazard. (K) Fire management and other policies enable Ngunnawal fire management and cultural practices, addressing: rights and responsibilities; cultural knowledge management; resources; training; risk assessments; communication and coordination; and, regulation. (R) Ngunnawal have access to Country and authority to undertake cultural land management including burning. (R)	Processes in place to protect Ngunnawal cultural knowledge, and manage if and when it is shared with government, the community and other land managers. Ngunnawal are undertaking cultural fire management. Ngunnawal are contributing to fire management. *Note, the changes needed for this climate-ready objective need to be determined by a Ngunnawal led process, as only they have the cultural authority to speak and care for cultural values, although all land managers have a responsibility in delivering the objective.*
Policy and planning to co-develop a framework to enable Ngunnawal land management practices. Initiate a series of pilot Ngunnawal burns to start to reawaken regular Ngunnawal burning of Country and build mutual understanding of Ngunnawal burning and government perspectives of the opportunities, benefits and risks. Examine how Ngunnawal burning practices can intersect with an evolving whole-of-landscape fire management framework for the ACT. Identify specific opportunities for Ngunnawal burning to contribute to fire management, both now and as fire conditions change, including understanding the limitations and necessary supporting governance and other arrangements. Monitor Ngunnawal burns, through Ngunnawal and Western lenses, to gain shared understanding of outcomes against multiple objectives. *Note that, due to ecological changes resulting from extended lack of Ngunnawal burning, it may take multiple cycles of burning and ecological responses on Country, before outcomes can be properly evaluated*		

Figure VI. Adaptation pathway for climate-ready objective #6

Key insights

The report discusses a range of key insights that emerged from the workshop deliberations and adaptation pathways analysis.

- **Anticipation and dialogue:** Collective anticipation and dialogue about the near- and longer-term implications of climate change for society and government may enable new

[8] The term 'reawakening' was chosen by Ngunnawal participants to emphasise that while Ngunnawal fire practice had been paused historically, the knowledge and tradition has not been lost - it just needs the opportunity to be reestablished.

approaches to be developed and trialled, before current approaches are overwhelmed by changing fire conditions. The intent is not to lock these specific long-term actions into current planning, but to highlight the whole-of-society nature of the *system changes* that would be required under climate change.

- **Don't delay:** Short—and medium-term risks should be addressed in the context of longer-term risks, which may be sudden and surprising. A deliberate strategy is required to drive the whole-of-society learning process necessary to prepare for future transformational changes.
- **Ngunnawal burning:** To be set up for success, Ngunnawal burning needs appropriate shared expectations, governance, institutional arrangements, and partnerships. There is potential for Ngunnawal burning to contribute to broader fire management objectives, possibly in a commercial role, and be undertaken for cultural reasons. However, uncertainties and complex governance issues need to be carefully explored to help realise the full potential without unrealistic expectations or responsibilities being assigned.
- **Uncertainties, ambiguities, and dynamic trade-offs**: Uncertainties, ambiguities, and trade-offs are an inherent part of anticipating and deliberating about transformational change and an essential part of successful long-term climate adaption. The near-term interventions developed in this analysis are designed to examine uncertainties, ambiguities, and trade-offs before they become critical issues when future climate change impacts are experienced. This report outlines particular uncertainties and ambiguities associated with 1) manipulating fire regimes, 2) enhancing and managing buffers, and 3) improvement in fire-resistance standards for buildings and open spaces. These uncertainties can be addressed by reducing them, to some extent, through research and deliberation, but more importantly through developing decision-making processes that accommodate the uncertainties.
- **Nature conservation:** Climate change is a fundamental challenge to how we conceptualise, plan, regulate, and achieve nature conservation outcomes. In the face of significant ecological change, the nature conservation challenge may need to become 'how do we steer ecological change to more desirable states', as opposed to 'how do we resist ecological change'. While significant and widespread ecological change occurs, it may be reasonable to aspire to minimise the loss of native species, maximise the number of native species in communities and the landscape, maintain the health or ecological

condition of ecosystems, and maintain extensive areas of native ecosystems with a diversity of communities.

- **Reducing *future* risk:** This report explores management and policy options for a future where the current fire and social context has changed, and there is a need and desire for significant 'step' changes in various areas where further reductions in risk might be possible. These build upon the ACT's existing strategies that seek to reduce bushfire risks to a reasonable and feasible extent in the current fire and social context.

Continuous research, technology development, learning, capacity building, foresight, and policy and management updates will be essential in response to both anticipated and occurring changes. Policy and management will also be updated as understanding increases about the effectiveness of different responses and as community expectations evolve in response to climate change and other drivers.

1. Introduction

Climate change poses far-reaching and unprecedented challenges for decision-making and planning. Climate change is already causing longer, more elevated, and more frequent periods of escalated bushfire danger,[9] and fire agencies have experienced unprecedented fire conditions with massively destructive effects.[10] In recent decades, large bushfires across southeastern Australia, including the ACT, have shown the potential for intense and widespread fires to cause significant detrimental impacts on nature, infrastructure, and people. These impacts are often long-lasting, biophysically and socially. The connection between anthropogenic climate changes and recent bushfires in Australia has been established.[11]

Climate projections for the ACT region suggest an increase in average temperature of up to 4.5°C and a decrease in rainfall of up to 25% may be possible by 2090.[12] These changes would be accompanied by increased days of extreme heat and elevated fire danger, extended periods of drought and more frequent and intense weather events. These changes would significantly increase the likelihood of fire in the landscape and are likely to amplify the risks to nature from other shocks and stressors.

While the rates and magnitude of future climate change are uncertain, it is anticipated that future change could result in conditions that promote significant and ongoing increases in the intensity, extent, and frequency of fires in the ACT region. To significantly reduce the risks associated with changing fire regimes to the people of the ACT and the things they value,[13] it is essential that action is taken now, through anticipating the various changes, engaging with partners, and beginning to prepare for ongoing change.

The Climate Adaptation for Nature (CAfN) initiative within the ACT Environment, Planning and Sustainable Development Directorate (EPSDD) has been led by the Office of Nature Conservation (ONC), with support from the Commonwealth Scientific and Industrial Research Organisation

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[9] Jones et al., Climate change increases the risk of wildfires. *ScienceBrief Review.* (2020). https://ueaeprints.uea.ac.uk/id/eprint/77982.

[10] Vallient, John. Fire Weather: A true story from a hotter world. Alfed A Knopf, Penguin Random House LLC, New York, 2023.

[11] van Oldenborgh, et al. "Attribution of the Australian bushfire risk to anthropogenic climate change." *Nat. Hazards Earth Syst. Sci.*, 21, (2021): 941–960.

[12] Climate Change in Australia, https://www.climatechangeinaustralia.gov.au/en/projections-tools/climate-analogues/analogues-explorer/ Accessed May 20, 2024.

[13] Fire regime: The history of fire in a particular vegetation type or area including the frequency, intensity and season of burning. It may also include proposals for the use of fire in a given area. (AFAC).

(CSIRO), working closely with EPSDD Environment, Heritage, Water Division (EHW) teams, including Parks and Conservation Service. The initiative aims to develop a systematic and effective response to the impacts of climate change, in which the knowledge, capacities, and processes for adaptation are embedded in the mainstream of ACT Government.

CAfN has been designed as a learning initiative, proceeding primarily through case studies — focused explorations that delve into the challenges of adaptation for specific issues, places, and topics in an inclusive, systems-based, and context-specific way.

Each case study has multiple objectives:

- providing insights about future change specific to the focal topic, which can be considered for incorporation in scheduled planning processes (such as, in the context of fire, the Strategic Bushfire Management Plan (SBMP) and the Regional Fire Management Plan (RFMP))
- building the capacity of participants to consider and deliberate about climate adaptation, including transformational change
- identifying the nature of the transformational adaptation challenge for nature conservation in the ACT, including revealing the supporting and inhibiting conditions in government and society, identifying priority partners for engagement, and testing engagement approaches.

This report captures results and insights from the first case study of the CAfN initiative, which explores possible pathways of responses to the prospect of climate change significantly increasing the likelihood of fire in the landscape.[14] The report outlines adaptation pathways to help the ACT Government and community navigate the challenge of living well with climate change. This case study intends to build capacity to anticipate the implications for management and society of changing fire regimes in the ACT. The primary focus of ONC is the risk to nature, but it is recognised that fire is a whole-of-system issue. Impacts on people and built and cultural assets are critically important, shaping how outcomes for nature can be achieved. Hence, this case study explored a

[14] In this report, fire is used broadly refer to fire in the landscape from a combination of prescribed burns, managed bushfires and uncontrolled bushfires. (See also Managed bushfire, Prescribed burn and Uncontrolled bushfire).

broad set of issues. The second CAfN case study on Namadgi National Park (NNP) is ongoing and aims to build capacity to embed climate adaptation into NNP Plans of Management.

This analysis *is preliminary* as the case study was a pilot implementation of the CAfN framework; it was limited in scope and resources and was not comprehensive in its coverage of climate and fire risk-related issues. The near-term interventions outline possible adaptation opportunities and barriers that could be considered in planning of fire and landscape management; they are not recommendations of actions that should be taken.

2. Method

The case study was co-produced by CSIRO and EHW, led by ONC. The process and some content was provided by CSIRO, and most of the content was provided by EPSDD staff. Two workshops and subsequent meetings were used to engage with experts from across EPSDD, including the PCS Fire Management Unit, ONC, and the EPSDD Traditional Custodian Engagement unit. The content was then integrated and synthesised by CSIRO and EPSDD.

The process used an adaptation pathways framework. The steps of the climate-ready analysis conducted through the workshops are illustrated in Figure 1A, and how it relates to implmentation of adaptation pathways in the real world is shown in Figure 1B. The process introduces and uses a series of key concepts useful for thinking about, deliberating over, and planning for potential transformational change (Box 2).

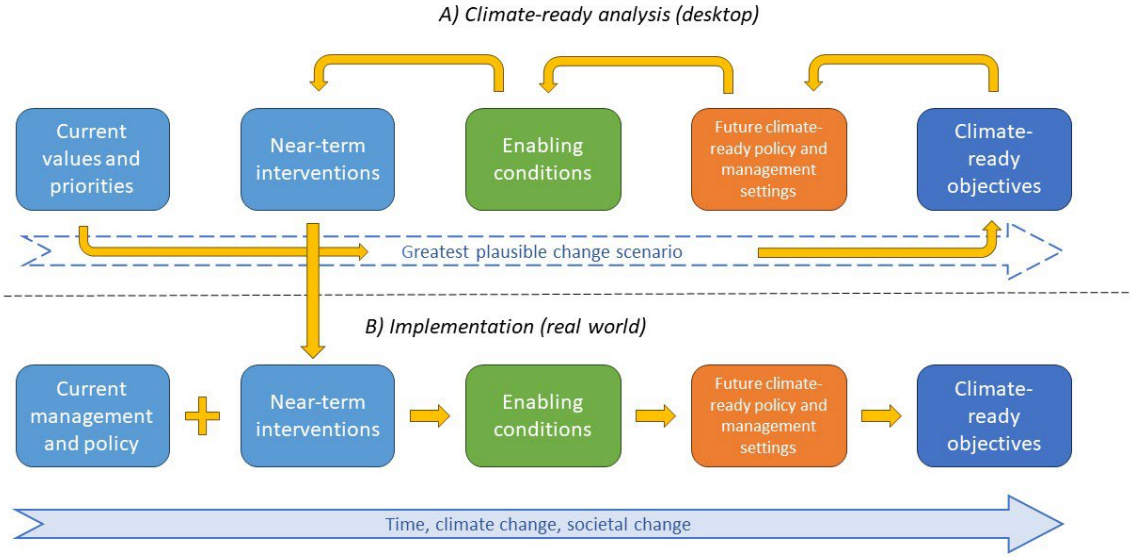

Figure 1 A and B. The climate-ready analysis and real-world implementation of adaptation pathways. A) The climate-ready analysis is conducted with experts, starting with values, working through a greatest plausible change scenario (dashed arrow), climate-ready objectives based on values that could persist, future climate-ready policy and management settings to achieve the objectives, enabling conditions needed for decision-makers to choose the actions, and near-term interventions in the current management and policy system that could help the enabling conditions develop. B) When implemented in the real-world, the near-term interventions can stimulate pathways of changes including societal condition that enable future policy and management settings necessary to live well with transformational climate change.

A scenario of *greatest plausible change* was developed and used to help participants explore future impacts of climate change on key values (nature, life, and property) to anticipate transformational responses that the ACT Government and society may require should current and emerging management strategies fail to sufficiently reduce fire risk in the future.

Long-term *climate-ready objectives* were scoped for the values, focussing on preserving values that could persist in the face of transformational change, as opposed to seeking to resist change15. These objectives were used to identify *climate-ready policy and management settings*, actions that may be needed in the longer term (e.g. over the rest of the century) for people of the

[15] Dunlop, M, Parris, H, Ryan, P, Kroon, F. "Climate-ready conservation objectives: a scoping study." National Climate Change Adaptation Research Facility, Gold Coast, (2013): 102

ACT to live successfully with the impacts of climate change. Many of these actions would be undertaken by the Government, but they would involve collaboration with businesses, other organisations, households, and individuals. Some of the actions identified as possibly being effective in the future are outside the set of fire, landscape, and urban management actions that are currently familiar and accepted in the ACT.

Key issues associated with increased fire risk[16] and implementing the future climate-ready policy and management settings were identified and used to develop future *enabling conditions.* Enabling conditions would need to be in place to support decision-makers in implementing effective adaptation. We used the "values, rules, knowledge" framework developed by Gorddard et al.[17] to categorise these enabling conditions. This framework recognises that, in general, the conditions that promote or hinder climate adaptation fall into the domain of values (i.e. what the public wants), rules (i.e. how laws/policies structure or restrict action), or knowledge (i.e. what we know how to do). Some of these enabling conditions amount to large changes with big impacts on what managers and the community are used to, and they would likely require long conversations and incremental change over many years. The case study then identified *near-term interventions* — actions that could be implemented within existing programs or with tangible new programs in coming years and would help contribute to establishing the enabling conditions. The near-term interventions are actions that could primarily be undertaken by EPSDD, often in partnership with other parts of government, businesses, researchers, and the community. With these enabling conditions in place, decision-makers are likely to be more able to implement effective responses to emerging fire[18] in the future. With the enabling conditions in place, decision-makers and the community will be less likely to take maladaptive actions – responses to change that may be effective in the near term but make it harder to respond effectively to larger changes in the future.

The (climate-ready) objectives and policy and management setting that future decision makers choose to adopt (*Figure 1*B) are likely to be different from those that have been anticipated. The near-term actions are designed to stimulate societal learning leading to changes in values, rules and knowledge, creating new enabling conditions. The learnings and changes that actually occur

[16] Fire risk: in this report, fire risk refers to the combination of the likelihood and consequences of fire.
[17] Gorddard, R., Colloff, M.J., Wise, R.M., Ware, D. and Dunlop, M. "Values, rules and knowledge: Adaptation as change in the decision context." *Environmental Science & Policy,* 57, (2016): 60-69.
[18] Fire conditions here refer to the set of prevailing fuel, weather and topographic conditions that influence the behaviour of a fire.

will be different from the ones that have been anticipated in this analysis, and they are likely to enable a range of additional strategies and objectives that have not yet been imagined. The intent of the pathways analysis and the near-term actions is to drive this process of societal deliberation and innovation opening up climate-ready options for future decision makers.

Box 2. Key concepts

Greatest plausible change scenario

A scenario of 'greatest plausible change'[19] is developed by extending climate trajectories of greatest concern to a point where the magnitude of change is significant for society and management, while ensuring that changes are consistent with current understanding of the system's physical, ecological, and social dynamics. No fixed timeframe applies to a greatest plausible change scenario. However, the scenario is unlikely to occur within one or two decades, and may occur towards the end of the century, or it could be avoided with successful reductions in global greenhouse gas emissions.

'Pathways' of actions can be developed, which include preparing for greatest plausible change while responding to smaller levels of change along the trajectory. Critically, articulating the adaptation pathway allows responses to the smaller changes to be planned, looking forward to the possibility of future more significant change rather than looking back to some past 'baseline' conditions.

Climate-ready objectives

Climate-ready objectives are feasible under significant climate change, and are based on accommodating inevitable change rather than resisting change. They focus on protecting values that could persist while change occurs rather than those likely to be lost. Along with accommodating significant change, climate-ready objectives need to accommodate increasing uncertainty and complexity, as well as multiple values that people hold for nature or the system of interest.[20]

Future climate-ready policy and management settings

[19] CSIRO. "Climate Compass: A climate risk management framework for Commonwealth agencies." CSIRO, Australia, 2018.

[20] Dunlop, M, Parris, H, Ryan, P, Kroon, F. "Climate-ready conservation objectives: a scoping study." National Climate Change Adaptation Research Facility, Gold Coast, (2013): 102.

Future climate-ready policy and management settings are actions that could be taken in the longer term to contribute to achieving the climate-ready objectives. These may include some current actions, some adjustment to current actions, and some new actions. It is likely that current policymakers, mangers, and the community with have little or no experience with many of these new actions, and there may be multiple barriers to choosing and implementing them.

Enabling conditions

Enabling conditions are factors in society that enable decision-makers to choose changes in management to support climate adaptation, such as actions toward achieving climate-ready objectives. Also referred to as the decision context, enabling conditions can be characterised as values, rules, and knowledge,[21] respectively corresponding to stakeholder support for an option, alignment with legislation, regulation, policy, standards and norms, and sufficient understanding of the consequences of implementing an option and technical know-how to be able to implement the option.

In the adaptation pathways framework, enabling conditions are the result of addressing barriers to change that might currently be in place. Enabling conditions, in this context, are typically not within the direct control of the person choosing between options. They come broadly from stakeholders, legislators, policymakers, industry bodies, scientists, and expert advisors – broadly reflecting society's attitudes and understanding.

Near-term interventions

Near-term interventions are actions to help shift decision contexts in a way that creates conditions to enable decision-makers or managers to choose options that are more effective under climate change. These actions are considered strategic interventions designed to provoke learning by people in society whose preferences and actions form the values, rules and knowledge that shape the availability of different options. These interventions could involve promoting specific options, but in the context of democratic governance, these interventions could involve providing information or engaging in learning experiences, to help people evolve their preferences and actions based on a better understanding of the challenges facing society in the future and the dilemmas facing decision-makers and mangers.

[21] Gorddard, R., Colloff, M.J., Wise, R.M., Ware, D. and Dunlop, M. "Values, rules and knowledge: Adaptation as change in the decision context." *Environmental Science & Policy,* 57, (2016): 60-69.

Where decision-makers are recipients of the enabling (and restricting) conditions, the near-term interventions reflect their agency to change those conditions. These interventions should be designed to be implemented within existing or planned programs and strategies. In many situations, it may take decades for the decision context to evolve sufficiently for some transformational adaptation options to be available to decision-makers, such as significant changes to the management of bushfires and the risk of fire to urban areas.

Adaptation pathways

Adaptation pathways is a term used to describe a strategy of deliberately creating options for future decision-makers and society based on enhanced and continuous learning about change, both anticipated and experienced.[22] Adaptation to significant climate change will involve large changes in decision-making and management that need to be supported by society and reflected in an enabling decision context. Given uncertainty about rates and fine details of change in the climate, their impacts on species, ecosystem, and fire regimes, and particularly people's preferences based on their evolving relationships with nature and fire, it is impossible to determine what future changes in management will be most effective or desirable. However, the broad direction, or directions, of such changes in decision-making can be anticipated and actively navigated. A key part of creating future options is identifying and avoiding current decisions that may make it harder to adapt in the future, even if they are attractive and effective in the near term (so-called maladaptation[23]).

3. Results

3.1 Greatest plausible change scenario

Trajectories of warming and drying, as anticipated in many climate projections for southeastern Australia, would likely lead to significant increases in elevated fire conditions and lengthening of the bushfire season. The scenario of greatest plausible change in this case study involves a significant increase in the occurrence of fire in the ACT. It is anticipated that improved technology and future changes in management will continue to be successful in rapidly suppressing most

[22] Wise, R.M., Fazey, I., Smith, M.S., Park, S.E., Eakin, H.C., Van Garderen, E.A. and Campbell, B. "Reconceptualising adaptation to climate change as part of pathways of change and response." *Global environmental change,* 28, (2014): 325-336.

[23] Maladaptation, in this context, refers to actions that might be taken to address one climate change issues, such as immediate or near-term climate impacts, but which inadvertently increase vulnerability by increasing future exposure to higher levels of climate change or reducing options for adapting to those impacts.

bushfires as fire danger conditions continue to elevate in coming decades. However, in this scenario, conditions eventually result in a sustained increase in the number of uncontrolled bushfires in extreme conditions, with the potential to become very large. Managing the likelihood and impact of such fires becomes an increasing challenge.

The scenario (Box 3) anticipates more frequent and extensive fires because of the general ecological relationship between climate and fire regime[24] – hotter and dryer climate leading to more frequent occurrence of weather and fuel conditions that are conducive to bushfires (their ignition, behaviour and spread), with vegetation changing in ways that may further enable the spread of fire.[25] This includes increased number of fires, increased annual area burnt and reduced average interval between fires.[26] This increase results from some combination of uncontrolled high-intensity bushfires, less intense bushfires that, while unplanned, are managed for strategic objectives, and prescribed burns. The balance between uncontrolled high-intensity bushfires and managed less-intense fires (both prescribed burns and managed bushfires) may change over time and will be significantly influenced by management.

The increased occurrence of fire in the landscape will significantly affect ecosystems, altering vegetation composition and structure, and altering litter accumulation and fuel dynamics; this in turn, will further affect subsequent fire behaviour and fire regimes. Changes in fire, along with changes in the climate, will lead to changes in the abundance and distribution of species and communities, significant declines in some species, expansion of other species (including invasive non-native plants and animals), possible loss of some threatened species, more species becoming threatened, and colonisation of species from outside the ACT region (again, including non-natives).

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[24] Bradstock, R.A. "A biogeographic model of fire regimes in Australia: current and future implications." *Global Ecology and Biogeography,* 19(2), (2010): 145-158.

[25] Includes compositional, structural and functional change, such as increased abundance of flammable species, decreased tree density and cover, increased understory and decreased litter decomposition.
Bowman, D.M., Kolden, C.A., Abatzoglou, J.T., Johnston, F.H., van der Werf, G.R. and Flannigan, M., "Vegetation fires in the Anthropocene." *Nature Reviews Earth & Environment,* 1(10), (2020): 500-515.
Barker, J.W., Price, O.F. and Jenkins, M.E., "High severity fire promotes a more flammable eucalypt forest structure." *Austral Ecology*, 47(3), (2022): 519-529.

[26] The mean number of years between fires has already been found to be decreasing.
Canadell, J.G., Meyer, C.P., Cook, G.D. *et al.* "Multi-decadal increase of forest burned area in Australia is linked to climate change." *Nat Commun* **12**, 6921 (2021)https://doi.org/10.1038/s41467-021-27225-4

Box 3. Greatest plausible change scenario for future fire in the ACT region

Fire

- Frequent extreme/catastrophic fire weather
- Much more frequent fire in the landscape, including intense and extensive bushfires
- More frequent intersection of fire and things we value
- Beyond the current firefighting, management, and coping capabilities of the government and the community

Biodiversity

- Widespread change in vegetation structure due to climate and fire
- Redistribution of communities and ecosystem types
- Turnover of species:
    - decline in some species, expansion of others
    - loss of some threatened species and some not currently threatened
    - many new threatened species
    - new species establishing from elsewhere

Fire will increasingly affect things people care about: species and ecosystems, ecosystem services, First Nations cultural sites and heritage, dwellings and other built infrastructure, and people's health and wellbeing. Increased smoke will also affect people directly and other activities, such as viticulture.

The nature of the changes in vegetation, ecological impacts, and impacts on other values will depend on the specific details of the fire regimes that occur. This will be a function of how climate change unfolds, vegetation responses to climate change, vegetation responses to fire, fire management, and ecological responses to fire management. While the dynamics of the natural process are impossible to predict in detail, we can be quite confident about the likely direction of

changes in response to drying and warming. In this scenario, fire regimes and vegetation responses were not specified precisely. Rather, the intention was to define the scenario in sufficient detail to provoke consideration of various changes in fire policy and management and, more broadly, changes in the ACT community's relationship with fire.

3.2. Themes of responses

Living successfully under the scenario of significantly increased fire activity would require new and enhanced management of fire risk spanning a wide range of types of response across government and the community. Participants in the case study developed and considered responses to the scenario under the three themes outlined below. The adaptation pathways (section 3.3) are developed under these three themes.

1. **Landscape-scale fire management to maintain a mosaic of different times since fire.**[27] Responses under this theme aim to reduce the intensity[28] and spread of uncontrolled bushfires[29] by managing vegetation structure and fuel loads[30] throughout the landscape. The rationale is that increased drying and warming is expected to lead to more frequent and larger fires. Management could be used to deliberately shift these changing fire regimes towards more frequent and extensive but *less intense* fires, so that inevitable bushfires during extreme and catastrophic conditions are *less intense and extensive*. This could be achieved through a combination of extensive prescribed burns and strategically managing some bushfires to achieve burning objectives (i.e. managed bushfires). It is anticipated that this would involve significantly more prescribed burning and changes to how some bushfires are managed.

2. **Stronger protection of built, cultural, and ecological assets from more frequent occurrence of uncontrolled fire.** This theme recognises that, despite enhanced fire management efforts, under the scenario there is likely to be more frequent occurrence of uncontrolled fire reaching urban areas and other assets because of fire

[27] Time since fire is the primary variable of concern for fire risk management and biodiversity, but this mosaic could include other characteristics of previous fires that have some legacy for the impacts of the next fire, including season, intensity and post-fire weather, and potentially characteristics of earlier fires.
[28] Fire intensity: The rate of energy release per unit length of fire front usually expressed in kilowatts per metre (Kw/m). (AFAC)
[29] Bushfire: Unplanned vegetation fire. A generic term which includes grass fires, forest fires and scrub fires both with and without a suppression objective. (AFAC)
[30] Fuel load: The oven dry weight of fuel per unit area. Commonly expressed as tonnes per hectare. (AFAC).

conditions becoming more extreme and an increased risk of more frequent and extensive managed fires escaping controls. Furthermore, while the ACT has best-practice measures to protect assets, standards could be raised to increase levels of protection. Increased asset protection can be achieved through two mechanisms. First, the current system of buffers[31] (including Asset Protection Zones)[32] could be enhanced to reduce fire spread and intensity and aid suppression adjacent to urban areas, other assets, and culturally important sites. The existing system of buffers could be enhanced by adjusting their form to allow for more effective fuel reduction, increasing their size, complementing with outer buffers designed to reduce fire intensity, ember production, and possibly smoke toxicity. Second, regulations and standards for the design, construction, and ongoing maintenance of buildings, backyards, suburbs, and open spaces could be enhanced to reduce their sensitivity to fire.

3. **Reawakened Ngunnawal fire management.** This theme recognises that as well as being important for Ngunnawal cultural wellbeing and the health of Ngunnawal Country, Ngunnawal burning has the potential to play a role in managing landscape fire regimes and maintaining buffers in the ACT and surrounds as the climate changes. Responses in this theme explored how to enhance Ngunnawal burning, combining cultural benefits, income and business opportunities for Ngunnawal and increasing ACT's fire risk management resources. The term 'reawakening' was chosen by Ngunnawal participants to emphasise that while Ngunnawal fire practice had been paused historically, the knowledge and tradition has not been lost, it just needs to be given the opportunity to be put into use.

Many existing fire management activities map to these themes. The case study sought to build on existing activities and explore new or enhanced actions at *a scale that would be effective in the face of the change scenario (Box 3).* These often correspond to a transformation in how fire and fire risk might be quantified and managed in the ACT *in the future*. Many of the future objectives and

[31] Buffer: An area of land on which fuels and other vegetation are managed to provide protection to surrounding lands and assets by reducing the intensity and spread of fire, enabling suppression and reducing the production of embers.
[32] Asset Protection Zones (APZ) are areas zoned specifically to enable management of fuel loads around a building or structure; they are a type of buffer.

activities identified would not be necessary to manage current fire risks, and many would not be feasible to implement with current community expectations and involvement, knowledge, and institutional arrangements.

3.3 Adaptation pathways

Adaptation pathways are presented for a series of climate-ready objectives. *The climate-ready objectives* (Table 1) are outcomes that would likely be feasible and effective in the face of the transformation associated with the greatest plausible change scenario.

Table 1. Themes of responses and climate-ready objectives

Overarching theme: Managing the impacts of changing fire regimes under climate change
Climate-ready objective #1: Minimise the social and environmental impacts of fire in the ACT, while climate change increases the likelihood of bushfire in the landscape
Theme 1: Landscape-scale fire management to maintain a mosaic of different times since fire
Climate-ready objective #2: Reduce the intensity and spread of uncontrolled bushfire through the establishment of an extensive mosaic of times since fire throughout the landscape, while the incidence of fire increases with climate change
Theme 2: Stronger protection of built, cultural, and ecological assets from more frequent occurrence of uncontrolled bushfire
Climate-ready objective #3: Reduce the likelihood of bushfire affecting valued assets through a system of enhanced buffers, while the incidence of uncontrolled bushfire in the landscape increases
Climate-ready objective #4: Design and maintain buildings and open spaces in the urban environments to resist the impact of fire, while the likelihood of extreme fire weather and uncontrolled bushfire increases
Climate-ready objective #5: Protect Ngunnawal cultural values[33] throughout the landscape, while the incidence of fire increases
Theme 3: Reawakened Ngunnawal fire management
Climate-ready objective #6: Ngunnawal land management is a significant feature of fire management in the ACT and surrounding region, contributing to both Ngunnawal cultural needs and broader societal fire management objectives, while fire regimes and ecosystems change in response to climate change

Actions designed to contribute to each objective in the face of the scenario are presented as *future climate-ready policy and management settings*. *Enabling conditions* are factors, including values, rules, and knowledge, that would assist decision-makers in adopting and implementing the future policy and management, if and when required. *Near-term interventions* are actions that could be

[33] Includes places, species and other features of cultural importance to the Ngunnawal community

undertaken in the current or subsequent planning cycles to create the enabling conditions for future management and objectives while continuing to manage for current objectives. In the tables below, for ease of representation, each *near-term intervention* is mapped to a specific *enabling condition* under a *climate-ready objective*. In reality, each near-term intervention might contribute to multiple enabling conditions and objectives. Additionally, as a suite, they all contribute to the enabling conditions described in the overarching theme.

3.3.1. Overarching theme: Managing the impacts of changing fire regimes under climate change

This overarching objective captures enabling conditions shared across climate-ready objectives and activities that are outside the direct scope of the SBMP and RFMP but can be influenced by these documents. Table 2 presents the overarching climate-ready objective, future policy and management settings that could contribute to the objective, corresponding enabling conditions, and near-term interventions.

Table 2 Climate-ready objective #1, enabling conditions, and near-term interventions

Climate-ready objective #1: Minimise the social and environmental impacts of fire in the ACT, while climate change increases the likelihood of bushfire in the landscape
Future climate-ready policy and management settings • Policies and processes accommodate future fire management conditions • Consideration of long-term climate, environmental, and ecological changes in planning • A shared narrative and objectives for the future • Ongoing dialogue among all stakeholders about changing fire risk and the evolution of the ACT community's relationship with fire • Ongoing evolution of rules and knowledge as fire conditions change • Sustainable workforce (resources, physical effort, smoke, stress) • Maintain community wellbeing (smoke, security/relationship with fire and fire risk)
Enabling conditions ***Values*** 1.1 Appreciation and understanding of future fire risk and associated impacts 1.2 Collective anticipatory capacity and awareness of cascading consequences ***Knowledge*** 1.3 Greater understanding of the impacts of smoke on health and wellbeing, particularly that of fire practitioners 1.4 Greater understanding across the community of the changing nature of fire, fire risk, and fire management ***Rules***

Climate-ready objective #1: Minimise the social and environmental impacts of fire in the ACT, while climate change increases the likelihood of bushfire in the landscape

1.5 Planning, strategic documents, and legislation anticipate and accommodate trajectories of change in climate, ecosystems, and fire regimes

1.6 Cross tenure approach to assessing and managing fire risk

Near-term interventions

1.1 Initiate long-term, place-based conversations among the community, fire practitioners, and government to:

- increase understanding about future fire and risk to life, property, and the environment, and the trade-offs between bushfire risk and impacts of enhanced activities to reduce risk (more frequent and extensive managed fire, enhanced buffers, stricter building standards)
- help evolve the community's attitudes and preference towards fire management commensurate to risks and impacts

1.2 Build capacity in government and the community to:

- anticipate and recognise more quickly any unintended consequences of decisions and actions
- make decisions in complex situations

1.3 Implement research programs, monitoring, and protocols to understand and minimise smoke impacts on health, recognising a likely increase in the exposure of the community and fire management staff to smoke

1.4 Provision of information and facilitation of dialogue in the community about the continually changing nature of fire, fire risk, and management

1.5 Develop tools and processes to enable planners to engage with trajectories of changing fire regimes, identify how management objectives and management effectiveness might be sensitive to changing fire regimes, and incorporate this into strategies:

- Incentivise long-term planning and collaboration between different parts of government to anticipate and accommodate climate change and emerging risks
- Develop scenarios and frameworks to help planners think about and incorporate long-term changes in fire regimes and ecosystems into strategies
- Develop policies and processes that allow fire practitioners to test new fire management strategies
- Analyse the ACT Bushfire Management Planning Framework and other related documents[34] to identify how they can:
    - anticipate and accommodate changes in species and ecosystems
    - enable changes in fire management standards to accommodate future fire regimes
    - create opportunities for greater Ngunnawal management of Country
    - address increased smoke impacts on the health of fire practitioners and the community

[34] Including the SBMP, RFMP and BOPs, as well as legislation including the Emergencies Act (2004), and other related documents

Climate-ready objective #1: Minimise the social and environmental impacts of fire in the ACT, while climate change increases the likelihood of bushfire in the landscape
○ respond to changes in community preferences and risk appetite[35] at different levels of decision-making • Review and update monitoring programs to be forward-looking and be able to differentiate between desirable and undesirable trajectories of change • Develop metrics to enable evaluation of fire management and conservation strategies, that accommodate significant ecological change, i.e. to identify where management has been successful despite changes in fire regimes and ecosystems 1.6 Continue and enhance communication, collaboration, and planning across tenures

3.3.2. Theme 1: Landscape-scale fire to maintain a mosaic of different times since fire

Maintaining a mosaic in the landscape of different times since fire, and potentially the season and intensity of the previous fire, is expected to reduce the proliferation, intensity, and spread of fire in extreme conditions. It is expected to enable suppression and increase the diversity of ecological responses to fire. Risk mitigation and ecological objectives would inform the implementation of the mosaic across the landscape.

Table 3 Climate-ready objective #2, enabling conditions, and near-term interventions

Climate-ready objective #2: Reduce the intensity and spread of uncontrolled bushfire through the establishment of an extensive mosaic of times since fire throughout the landscape, while the incidence of fire increases with climate change
Future climate-ready policy and management settings • Fire regimes are managed to be in equilibrium with climate as it changes[36], i.e. more frequent fire and shorter fire intervals across the landscape • Program of fire management integrating extensive prescribed burning and the management of bushfire to achieve burning objectives, rather than a default objective of rapid suppression
Enabling conditions ***Values*** 2.1 Community and expert support for more frequent and extensive prescribed burning in the landscape and the use of bushfire to achieve a desired time-since-fire mosaic ***Knowledge*** 2.2 Understanding of the ecological impacts of large-scale prescribed burning and how to manage these

[35] Risk appetite is the amount of risk that an entity is willing to accept or retain in order to achieve its objectives. Determining and articulating an entity's risk appetite assists entities to make better choices by considering risk more effectively in decision-making.

[36] Bradstock, R.A. "A biogeographic model of fire regimes in Australia: current and future implications." *Global Ecology and Biogeography,* 19(2), (2010): 145-158.

Climate-ready objective #2: Reduce the intensity and spread of uncontrolled bushfire through the establishment of an extensive mosaic of times since fire throughout the landscape, while the incidence of fire increases with climate change

2.3 Knowledge about managing larger fires in more remote areas, and supporting tools and resources such as fire behaviour forecasting, access, enhanced suppression capabilities

2.4 Knowledge about protecting and maintaining older post-fire age classes areas and other areas with high conservation value that are sensitive to fire

Rules

2.5 A clear understanding of risks and responsibilities for managing more frequent and extensive fires

2.6 Success and failure of fire management objectives are redefined to accommodate climate change and its expected impact on fire regimes and ecosystems

2.7 Where appropriate, bushfires are allowed to be managed to contribute to landscape fire objectives, as opposed to being rapidly suppressed

2.8 Policy and processes enable more agile prescribed burning, use of Ngunnawal fire practices, and management of bushfire to meet fire management objectives

2.9 Managers can conduct larger-scale prescribed burns with due consideration of their contribution to bushfire and ecological risks

Near-term interventions

2.1 and 2.5 Initiate and sustain dialogues within and between the community, government, and fire management agencies about how fire conditions may evolve under climate change, how risks and management opportunities will change, and managing a landscape-scale mosaic of times since fire, to develop a shared understanding and inform the evolution of preferences and risk appetites

2.2 Develop research and partnerships with other fire agencies in Australia and around the world, to understand:

- under what climatic and vegetation conditions is it feasible and sustainable for management to shift fire regimes towards 'more frequent and less intense fire'
- the outcomes from alternative strategies (e.g. frequent fire versus a suppression strategy with periodic failure)
- the ecological and ecosystem services implications of alternative fire management strategies, and their risks

2.3 and 2.7

- Undertake research on managing bushfire to meet land management objectives, including feasibility, management methods, risks, outcomes, fire-behaviour forecasting requirements, and suppression resource requirements
- Undertake analyses of the social, policy, and legal implications of managing bushfire to meet land management objectives
- Develop fire regime models and simulations to enable a better understanding of the dynamics and trade-offs, under different climate change scenarios, of different large-scale mosaics of times since fire

Climate-ready objective #2: Reduce the intensity and spread of uncontrolled bushfire through the establishment of an extensive mosaic of times since fire throughout the landscape, while the incidence of fire increases with climate change
• Build capacity to monitor and predict fire behaviour and hazards in real-time and at a fine scale throughout the landscape to guide decision-making about suppressing or managing bushfire • Undertake trials of more frequent and larger prescribed fire, to build skills, understand capability and resource requirements, identify and assess fuel break and access needs, assess ecological responses and better understand risks 2.4 • Understand the ecological value of older post-fire age classes in a future with more frequent fire where most of the landscape will be frequently burnt • Investigate management strategies for maintaining areas with older post-fire age classes in a dynamic mosaic of times since fire, including feasibility and balancing these with other fire management objectives 2.6 Develop metrics to evaluate fire management and conservation success and failure that accommodate significant ecological change 2.8 Identify opportunities and impediments to enable more agile prescribed burning, use of Ngunnawal fire practices, and management of some bushfire to meet fire management objectives 2.9 • Provide training and undertake trials to build skills and resources to conduct larger prescribed burns and to manage bushfire to meet objectives of landscape-scale fire management • Develop assessment processes and management guidelines about acceptable risks and impacts of larger prescribed burns

3.3.3. Theme 2: Stronger protection of built, cultural, and ecological assets from more frequent occurrence of uncontrolled fire

Stronger protection from fire can come from an enhanced system of buffers (Table 4) and design, construction, and maintenance of buildings and open spaces to increase their ability to resist fire (Table 5). Special attention may be required to ensure Ngunnawal cultural values are protected from increased fire in the landscape, both planned and unplanned (Table 6).

Table 4 Climate-ready objective #3, enabling conditions, and near-term interventions

Climate-ready objective #3: Reduce the likelihood of bushfire affecting valued assets through a system of enhanced buffers, while the incidence of uncontrolled bushfire in the landscape increases
• Future climate-ready policy and management settings • Enhancing the system of buffers around urban areas and other key built infrastructure so that it is more effective in the face of increased frequency of fire intersecting with the urban interface during more extreme fire conditions • Buffers are readily adapted over time, as necessary, in response to evolving community preferences, improvements in management techniques, and continuing changes in climate and fire risk • Buffers meet multiple objectives (aesthetics, recreation, biodiversity, easy maintenance) while having fire resistance and suppression as the primary consideration • Capacity and resources for effective management of the system of buffers, including hazard reduction and fire suppression
Enabling conditions ***Values*** 3.1 Widespread support for enhanced buffers around urban areas that prioritise fire risk reduction while also supporting aesthetic, recreation, and biodiversity objectives 3.2 Acceptance of the need for regular maintenance in buffers to manage fire risk, possibly including hazard reduction burning of buffers and the resulting smoke ***Knowledge*** 3.3 Technical knowledge about the design of buffers that are effective in the face of more extreme fire conditions, easy to maintain, resilient (i.e. not require restoration or rebuilding after fire), and can be further enhanced over time 3.4 Community understanding about the benefits of, and trade-offs associated with, different buffer designs and management arrangements 3.5 Knowledge about maintaining multiple values (aesthetic, recreational, cultural, biodiversity) while managing buffers primarily for fire risk 3.6 Fire sensitive assets in the landscape are mapped and prioritised, including built, cultural, and ecological assets ***Rules*** 3.7 Development codes and regulations include buffers that are designed to be adapted over time, as values evolve, management techniques improve, climate change continues, and fire risk changes, including planning for possible future expansion of buffers around new developments without further encroaching on areas set aside for conservation 3.8 Dedicated resourcing is available for maintenance and hazard reduction in buffer zones around urban areas and other assets, as the demand changes over time 3.9 Shared responsibility across land tenures for managing fire risks

Climate-ready objective #3: Reduce the likelihood of bushfire affecting valued assets through a system of enhanced buffers, while the incidence of uncontrolled bushfire in the landscape increases

3.10 Regulations allow managers to be opportunistic and responsive in fuel management activities in buffers around urban areas and other assets

3.11 Hazard reduction plans are in place for priority assets in the landscape, commensurate with changing fire risk

Near-term interventions

3.1, 3.2 and 3.4

Initiate conversations with the community, in a place-based way, about:

- future fire risk
- the benefits and costs of future enhancement of the buffer system around urban areas, including how they are designed, managed, and their size
- how buffer zones could be designed and managed primarily for fire risk reduction, but also for balancing aesthetic, recreation, cultural, and ecological values
- frequent and intensive fuel management activities in the buffer zone, possibly including prescribed burning

3.3 and 3.5

Generate knowledge with modelling and experiments about:

- managing buffers for multiple objectives as fire conditions become more extreme, including reducing fire risk, ease of suppression, amenity, biodiversity, ease of management (physical, regulatory, cost), reducing the impacts of smoke from hazard reduction burning, resilient to fire (don't need to be rebuilt), reducing ember creation during bushfires
- Modelling of fire behaviour in buffers under different fuel management strategies, as fire conditions become more extreme

3.6 and 3.11

- Identify cultural, ecological, and built assets in the landscape that are fire sensitive and need hazard reduction plans
- Develop an assessment process based on values and an evolving understanding of fire risk to prioritise assets and identify actions that need enabling with hazard reduction plans

3.7

- Build a case for future enhancement to the system of buffers, including possible expansion or adaptation, anticipating future fire conditions
- Integrate future enhancement of buffers into urban planning and development for new developments, and developing enhancement plans for existing developments, where needed
- Establish offsets for the ecological impacts of enhancing buffers
- Revise design standards for buffers, including improved effectiveness, multiple objectives, and future expansion and adaptation as fire risk increases
- Develop designs for buffers that can be easily enhanced over time

Climate-ready objective #3: Reduce the likelihood of bushfire affecting valued assets through a system of enhanced buffers, while the incidence of uncontrolled bushfire in the landscape increases

3.8 Review the emerging need for maintenance, hazard reduction, and fire suppression in the buffer zone, including increased mowing demand in wet years and more frequent years of higher fire risk
 	
3.9
• Implement a cross tenure approach to assessing residual risk from hazard reduction
• Identify where landholders, including rural leases, can contribute to reducing fire risk to surrounding areas
• Initiate conversations with landholders to explore and increase awareness of:
  o concepts of co-ownership of risk and shared responsibility
  o the multiple values held for different land use types and trade-offs between management objectives, such as production, hazard reduction, and biodiversity
 	
3.10
• Build capacity to be more responsive in hazard reduction, including:
  o better and finer-scale weather and moisture monitoring
  o better smoke monitoring
  o in-house capacity for residual risk modelling on annual and seasonal time scales
  o ability to use hazard reduction burning in buffers opportunistically, where appropriate, including clear policy about (enabling) generation of smoke
  o monitoring and evaluation
• Clarify roles for:
  o buffer design, construction, and management
  o built asset standards and maintenance
  o urban precinct planning and implementation
  o urban precinct maintenance
  o management of buffers around assets across tenures throughout the ACT
  o regulation and enforcement of standards

Table 5 Climate-ready objective #4, enabling conditions, and near-term interventions

Climate-ready objective #4: Design and maintain buildings and open spaces in the urban environments to resist the impact of fire, while the likelihood of extreme fire weather and uncontrolled bushfire increases
Future climate-ready policy and management settings • Development codes, standards, and regulations for suburbs, buildings, and open spaces are designed to meet anticipated future fire risk • Fire standards are well understood and transparent and provide effective incentives for exceeding minimum regulated levels (e.g., enabling better designs, insurance discounts, price premiums, etc.) • Formal processes are in place for assessing and mandatory disclosure of compliance to standards

Climate-ready objective #4: Design and maintain buildings and open spaces in the urban environments to resist the impact of fire, while the likelihood of extreme fire weather and uncontrolled bushfire increases

- Fire standards for open space apply to design and management, and to public and privately managed land
- Periodically revised codes and standards are enforced for new *and existing* buildings and open space

Enabling conditions

Values

4.1 Balancing of multiple objectives in the urban environment that accommodates the realities of changing climate and future fire risk: fire resistance, shade, asset protection, Ngunnawal cultural values, aesthetics and biodiversity

Knowledge

4.2 Community understanding of the benefits and trade-offs of maintaining fire-resistant urban green space, including in backyards

4.3 Long-term risks and benefits of construction choices are visible in near-term property decisions

Rules

4.4 Standardised processes for assessing and reporting on fire risk rating of existing buildings and open spaces, to inform compliance, insurance, investors, the market, the community, and fire planning

4.5 Building codes are designed for anticipated future fire conditions rather than contemporary or historic conditions

4.6 Process are in place to enable uplifting of existing buildings and open space to new standards, when developed

4.7 Fire resistance codes for open space including backyards, business, and public space, to enable design, maintenance, assessment, reporting, compliance, and continuous improvement

Near-term interventions

4.1 and 4.2

- Engage with the community about future fire risk in the urban environment to develop a shared narrative about managing multiple objectives in the urban landscape in the face of climate change and its impact on fire regimes
- Begin dialogues about household and personal costs and benefits of meeting different building standards, such as the short-term costs of retrofitting vs. long-term saving in insurance, averted fire-related losses
- Analyse the long-term societal cost and benefits of implementing enhanced building and open space codes, in new and existing developments, including the costs of not acting, retrofitting costs, insurance costs, loss and suffering, impact on amenity (also enabling conditions 4.6)

4.3 and 4.4 Develop a sliding rating scale (like energy efficiency ratings) for fire standards for buildings and open space, to provide a transparent and robust incentive for increasing the fire resistance of assets. For example, a scale that relates directly to the reduction in risk from

Climate-ready objective #4: Design and maintain buildings and open spaces in the urban environments to resist the impact of fire, while the likelihood of extreme fire weather and uncontrolled bushfire increases
exceeding the minimum design standard for the Bushfire Attack Level (BAL) allocated to a site, and can be interpreted and trusted by prospective purchases, insurers, lenders, etc. 4.5 Research to clarify the residual risk for building constructed to different standards in the face of different fire conditions, including future conditions (to underpin the action above) 4.6 Engage community about conforming to, and voluntarily exceeding, new standards as they are revised in the face of changing fire conditions, including risks, costs, benefits, responsibilities, and incentives 4.7 Engage community about managing backyards and open space in the context of future fire conditions, including risks, standards, responsibilities, incentives, and enforcement (e.g. combining with household information programmes, like *Climate-resilient city Climate-wise landscapes* information,[37] or through the *Mingle* program [38])

Table 6. Climate-ready objective #5, enabling conditions, and near-term interventions

Climate-ready objective #5: Protect Ngunnawal cultural values[39] throughout the landscape, while the incidence of fire increases
Future climate-ready policy and management settings *Note: the changes needed for this climate-ready objective need to be determined by a Ngunnawal led process, as only they have the cultural authority to speak and care for cultural values, although all land managers have a responsibility in delivering the objective.*
Enabling conditions ***Values*** 5.1 Widespread appreciation that fire management, and other land management, is on Ngunnawal Country and affects cultural values ***Knowledge*** 5.2 Awareness of cultural assets which may need protection from fire ***Rules*** 5.3 Processes for sharing appropriate levels of Ngunnawal knowledge with non-Ngunnawal fire and land managers 5.4 Cultural values are considered in hazard management and incident responses
Near-term interventions 5.1 Develop processes to increase fire managers' understanding of Ngunnawal values

[37] ACT Government. "Climate choices". Accessed May 20, 2024. https://www.climatechoices.act.gov.au/resilience-and-extreme-events/climate-resilient-city

[38] Mingle is a community development program for new estates in the ACT. ACT Government. ACT Government. "Mingle". Accessed May 20, 2024. https://suburbanland.act.gov.au/home-buyers-and-builders/mingle

[39] Includes places, species and other features of cultural importance to the Ngunnawal community

Climate-ready objective #5: Protect Ngunnawal cultural values[39] throughout the landscape, while the incidence of fire increases
5.2 and 5.3 Build capacity and processes in EPSDD to ensure appropriate access to knowledge about Ngunnawal cultural values, including who has access, under what circumstances, and what cultural competencies are required, so they can be readily considered in planning and included in datasets, as appropriate 5.4 • Develop processes to embed a Cultural Values Officer within Incident Management Teams and/or on-ground before and during planned burns and other fuel management operations • Develop processes to embed Ngunnawal values in strategic and operations planning

3.3.4. Theme 3: Reawakened Ngunnawal fire management

Ngunnawal burning has the potential to play a role in managing landscape fire regimes and maintaining buffers in the ACT and surrounds as the climate changes.

Table 7. Climate-ready objective #6, enabling conditions, and near-term interventions

Climate-ready objective #6: Ngunnawal land management is a significant feature of fire management in the ACT and surrounding region, contributing to both Ngunnawal cultural needs and broader societal fire management objectives, while fire regimes and ecosystems change in response to climate change
Future climate-ready policy and management settings *Note: the changes needed for this climate-ready objective need to be determined by a Ngunnawal-led process, as only they have the cultural authority to speak and care for cultural values, although all land managers have a responsibility in delivering the objective* • Processes in place to protect Ngunnawal cultural knowledge, and manage if and when it is shared with government, the community, and other land managers • Ngunnawal are undertaking cultural fire management • Ngunnawal are contributing to fire management
Enabling conditions ***Values*** 6.1 Ngunnawal land management knowledge is valued by fire and land management agencies and the broader community ***Knowledge*** 6.2 Widespread understanding about Ngunnawal land and fire management practices, including what it involves and its value to Ngunnawal and Country 6.3 Understanding how Ngunnawal fire practices may be able to contribute to wider fire and land management objectives 6.4 Ngunnawal fire is recognised as an essential part of the landscape and as an ecological service being provided rather than a hazard

Climate-ready objective #6: Ngunnawal land management is a significant feature of fire management in the ACT and surrounding region, contributing to both Ngunnawal cultural needs and broader societal fire management objectives, while fire regimes and ecosystems change in response to climate change

Rules

6.5 Fire management policies enable Ngunnawal fire management and cultural practices, addressing: rights and responsibilities, cultural knowledge management, resources, training, risk assessments, communication and coordination, and regulation

6.6 Ngunnawal have access to Country and authority to undertake cultural land management including burning

Near-term interventions

6.1 and 6.2

- Facilitate yarning, other dialogues, and communication between Ngunnawal fire practitioners, land managers, and the broader community to build understanding and appreciation of Ngunnawal fire practices and knowledge about Country

6.3

- Identify specific opportunities for Ngunnawal burning to contribute to fire management throughout the ACT and surrounding region, both now and as fire conditions change, including understanding the limitations and necessary supporting governance and other arrangements
- Monitor Ngunnawal burns, through Ngunnawal and Western lenses, to gain a shared understanding of outcomes against multiple objectives

6.4

- Undertake education and dialogues about re-establishing Ngunnawal fire as an integral part of the landscape, including that smoke from Ngunnawal burning is an indicator of an ecological service being provided by Ngunnawal

6.5

- Initiate a series of pilot Ngunnawal burns to:
    - make a start on reawakening regular Ngunnawal burning of Country
    - build mutual understanding of Ngunnawal burning and government perspectives on the opportunities, benefits, and risks
    - explore how Ngunnawal burning practices can intersect with an evolving whole-of-landscape fire management framework for the ACT
    - begin to understand the governance and institutional needs to enable successful Ngunnawal burning

  Note: due to ecological changes resulting from extended lack of Ngunnawal burning, it may take multiple cycles of burning and ecological responses on Country, before outcomes can be properly evaluated.

6.6

- Engage with Ngunnawal to understand the impediments to accessing Country
- Co-develop a framework to enable Ngunnawal land management practices

4.Discussion

Adapting to the increasing likelihood of fire in the landscape because of climate change will be complex. This case study used an adaptation pathways approach to explore the implications of changing fire regimes in the ACT and scope a range of responses to this challenge. It sought to build capacity in EPSDD to anticipate, deliberate about, and plan for uncertain futures resulting from climate change. Given that fire is a whole-of-system issue, while this case study focused primarily on risks to nature, it also considered a broad set of issues, including impacts on built assets, cultural values, and people more broadly.

This analysis is *preliminary*, as the case study was a pilot implementation of the CAfN framework, it was limited in scope and resources, it was not comprehensive in its coverage of climate and fire risk-related issues, and participation/consultation was limited to staff from the ACT EPSDD. Engaging with a wider set of stakeholders would provide additional insights and perspectives about managing future fire in the ACT.

The case study explored the challenges associated with an increasing occurrence of environmental conditions that would increase the likelihood of bushfire and the associated risks confronting the community and government in the ACT. The analysis explored responses that may be effective if and when current approaches, enhanced with emerging technologies, are unable to sufficiently reduce the risks arising from changing fire conditions. The *greatest plausible change* scenario for fire in the ACT (Box 3) was driven by a hotter dryer climate with more intense and frequent fire leading to significant ecological and societal impacts. Three themes of responses were developed: 1) landscape-scale fire to maintain a mosaic of different times since fire, 2) stronger protection of built, cultural, and ecological assets, and 3) reawakened Ngunnawal fire management. A set of *climate-ready objectives* was mapped to the three themes, each with *future climate-ready policy and management settings*, *enabling conditions* characterised as societal values, rules and knowledge, and *near-term interventions*. These final elements are adaptation actions that could potentially be undertaken by EPSDD, and partners, within current or planned programs or strategies. These actions are intended to help set in place the system-wide learning about future fire necessary to provide society, managers, and decision-makers with effective adaptation options if and when changing fire regimes begin to have transformational impacts on the ACT.

The adaptation pathway analysis has identified near-term actions that are incremental (i.e. no great near-term change from the status quo), but that seek to programmatically enable longer-term transformational decision-making. When incorporated into planning, the near-term interventions:

- enable collective anticipation and dialogue by provoking new understanding about future fire and continual re-evaluation of expectations and preferences
- accelerate the process of learning about living successfully with future fire conditions
- help examine key uncertainties, ambiguities, and trade-offs *before* they become critical issues from the experienced impacts of climate change.

Understanding the range of implications for society and government and the breadth of associated potential near-term interventions is important to ensure fire, land management, and urban planning consider future fire in a way that is holistic, robust to uncertainty, adaptable, and responsive to the needs and expectations of the ACT community.

4.1 Anticipation and dialogue

The intent in scoping future policy and management settings and enabling conditions in this analysis is to stimulate collective anticipation and dialogue about the near- and longer-term implications for society and government about changing fire regimes, and to enable new approaches to be developed and trialled. The intent is not to lock these specific long-term actions into current planning. Some of the changes we have described as potentially effective in addressing long-term changes in fire regimes may also be effective in the near term. These options could be considered in current planning if they align with community preferences, are enabled by legislation and policy, and managers have the knowledge required to implement them. Some of the anticipated policy and management options might never be adopted, but exploring them and their enabling conditions will help formulate alternative options that have not yet been anticipated.

Anticipating future change and engaging in dialogue can also be an effective way to examine assumptions about the future, including assumptions that future conditions, risks, and values will remain the same. It similarly helps test assumptions that present day policy and management actions would be effective under future fire regimes.

It is expected that this collective anticipation, dialogue, discovery, and re-evaluation process would occur continually over decades, with the intention of enabling decision-makers to be more proactive about managing fire risk. Continuous research, learning, and policy and management updates will be essential in response to anticipated and occurring changes, increased understanding about the effectiveness of different responses, and evolving community expectations in response to climate change and other drivers.

Many of the future policy and management settings and issues canvassed in the enabling conditions are beyond the scope or direct control of ONC, EPSDD, or the ACT Government. This analysis highlights the whole-of-society nature of the *system changes* that would be required if the impacts of climate change are as significant as outlined in the greatest plausible change scenario. While each household, land manager, and agency will have a role to play, many of the issues will have to be deliberated on and addressed across different groups in the community, economic sectors, government directorates and with the ACT's neighbours.

4.2 Don't delay

While the transformational impacts of climate change may be many decades away, or may not materialise at all, this adaptation pathways analysis illustrates that successfully managing those anticipated impacts would require changes across society and government that may themselves take decades. As well as actions to address current and near-term risk, deliberate strategies are required to drive the whole-of-society learning needed for longer-term transformational changes. In many cases, considering and preparing for such changes would be likely to also significantly reduce near-term fire risk; starting to prepare for these changes sooner will also reduce risks associated with changes occurring faster than anticipated.

There is a significant risk in only focussing on current, or near-term, fire risks associated with current fire conditions, vegetation, and community expectations. Delaying action in anticipation and preparing for significant future changes risks:

- sustained social, ecological, cultural and economic loss and suffering as a result of current fire risk management practices being repeatedly overwhelmed as conditions change in the future
- missed opportunities to develop alternatives in a measured, informed, and deliberative manner, and implement them in a timely manner when needed

- maladaptation arising from continued status quo planning and short-term adaptation leading to additional (yet foreseeable) barriers to long-term adaptation. For example, enhancing suppression capability may reduce near-term fire risk; however, if this delays anticipation of the need to enhance urban design and building standards, it may result in an increase in the number of houses that are underprepared for future fire risk.

4.3 Ngunnawal burning

It is important that Ngunnawal burning is set up for success, with appropriate shared expectations, governance, institutional arrangements, and partnerships. There is potential for Ngunnawal burning to contribute to broader fire management objectives, possibly in a commercial role, as well as being undertaken for cultural reasons. However, there are uncertainties and complex governance issues that need to be carefully explored to determine what role Ngunnawal burning can realistically play in contributing to broader ACT fire objectives, and to help realise the full potential of Ngunnawal burning without creating unrealistic expectations or responsibilities. This will require close partnership in the development of future Ngunnawal burning programs, with some aspects led by the community and others led by the government.

4.4 Uncertainties, ambiguities, and dynamic trade-offs

The future climate-ready policy and management settings foreshadowed here were identified as having the potential to reduce the risk of fire under the greatest plausible change scenario, if they can be successfully implemented. However, there are many uncertainties, ambiguities, and trade-offs associated with this. It is unknown exactly how a changing climate will affect fire regimes or how effective any particular management strategy will be in the future. Changing contexts are likely to affect community preferences for how competing values might be traded off. Various concepts, terms, and assumptions that people assume are fixed or agreed may be challenged by changing fire regimes.

Issues like these are an expected part of anticipating and deliberating about transformational change. Many of these issues do not arise when addressing short-term change, as the context remains unchanged. The presence of these issues can be confusing or uncomfortable and create a disincentive for people to engage with long-term or transformational change. However, discovering, unpacking, and working through such issues is an essential part of successful long-

term climate adaptation. For example, discovering an ambiguity in terminology might indicate that collective deliberation is required to understand what is changing, and why the ambiguity has arisen, and what other current understandings or assumptions that may not hold in the future. This process can develop new shared concepts and language that can accommodate anticipated changes and enable more effective deliberation and planning. Some uncertainties may be able to be reduced through research, monitoring and deliberative processes, but it is likely to become increasingly important for analysis, planning and decision-making processes to be developed that accommodate increasing uncertainties.

The near-term interventions developed in this analysis are designed to stimulate this process *before* the uncertainties, ambiguities, and trade-offs become critical issues from the experienced impacts of climate change. Several issues with key uncertainties identified in this analysis are discussed below.

4.4.1 Manipulating fire regimes

There are significant uncertainties associated with using more frequent fire to achieve vegetation conditions that reduce the expected intensity and spread of bushfire during extreme conditions (Climate-ready objective #2).

1. It is uncertain how feasible it is to actively manipulate fire regimes significantly, for example, using larger prescribed burns and managed bushfires to reduce the average times since fire and increase the diversity of times since fire across the landscape. It is unclear what resources and possible additional fire trails may be required to do this, or the biodiversity impacts of both the burning and additional fire trails, and the risks and liabilities from (possible) increased likelihood of managed bushfire 'escaping'.
2. It is uncertain to what extent achieving such a mosaic would drive vegetation and fuel changes that would significantly reduce the intensity and spread of bushfire in extreme conditions. It is even possible that it may increase the intensity of bushfire.[40] While there may be a general tendency across Australia for increasing aridity and increasing fire frequency to be associated with reduced fire intensity, it is unclear what relationship will

[40] Barker, J.W., Price, O.F. and Jenkins, M.E., "High severity fire promotes a more flammable eucalypt forest structure." *Austral Ecology*, 47(3), (2022): 519-529.
Lindenmayer, D. and Zylstra, P. "Identifying and managing disturbance-stimulated flammability in woody ecosystems." *Biological Reviews*, *99*(3), (2024): 699-714.

emerge for the ACT between drying, vegetation, fire frequency, and fire intensity region as the climate changes.

3. It is uncertain if the community would accept increased smoke production and impacts on park access resulting from increased fire activity.

Some of these uncertainties may be investigated with fire and vegetation modelling. Experiments could potentially be used to test methods for managing larger burns, the ecological impacts of more frequent fire in different landscape settings, and the impact that different times since fire have on bushfire intensity and spread. Such experiments would take many decades, as they would require multiple fire cycles. It may also be useful to learn from and share experiences with other jurisdictions and undertake modelling and experimental research collaboratively, across vegetation types and climate zones.

4.4.2 Managing buffers

There is currently a sophisticated system of buffers around urban areas in the ACT, which has been carefully designed, including enhancement after the 2003 bushfires. It has dedicated resources for maintenance and is audited. These buffers are generally 60 m wide, which is regarded as being very effective, especially for reducing the radiant heat load on buildings. The main residual risk to buildings is from ember attack, and significantly reducing this risk may require buffers of 100 m or more. In some cases, implementing such a buffer would require significant vegetation clearing in areas of high amenity and ecological value in the conservation estate; other forms of control that reduce ember production from bark in these zones may also be possible.

While increasing the size of buffers or adjusting their form to aid with maintenance and further reduce risk may be feasible in some places around urban areas, this is likely to have impacts on amenity, recreation and conservation values. Current uncertainties about enhanced buffers include:

- the amount of residual bushfire risk would be reduced
- the impacts on amenity and conservation values
- the extent to which reducing fire risk might affect building value and insurance costs
- community preferences regarding these benefits and costs in the context of changing fire regimes.

These uncertainties could be partially addressed with research and trials, for example trialling different buffer forms with extensive community engagement and assessing the impacts on biodiversity and amenity, and experiments about ember and smoke production. However, ultimately, community acceptability will be hard to assess until fire regimes and risks from them have begun to change. This suggests the need to create *the option* to implement improvements in the future. There may also be a need to use social science methods to assess changing community preferences on a location-by-location basis to inform a program of buffer renewal.

4.4.3 Building construction and urban open space

There are already best practice codes and standards for urban design, building construction and open spaces in fire risk zones in the ACT. As standards are now higher than in the past, when new suburbs are developed beyond existing suburbs, an increase in the standard of buildings on the urban fringe interface is automatically achieved. However, in many areas, the average level of building standard lags behind current standards, and it improves slowly as the existing housing stock is replaced or renovated.

As fire risk increases in the ACT and around Australia, it is likely that demand for greater fire resistance will increase from governments, insurance providers, residents and the owners of houses and other infrastructure. It is also likely that innovation will lead to improved methods for increasing fire resistance. As this occurs, it is likely that standards will increase for infrastructure. However, as standards improve, there will continue to be an issue of lagging standards of older infrastructure. Experiments could be undertaken with incentives to improve the standard of existing buildings and develop designs that anticipate and enable future upgrading of fire protection elements.

Increasing the fire resistance of open space, including backyards, may be physically easier to achieve but requires ongoing maintenance, and it may involve significant amenity trade-offs. It is unclear if open space designs can be developed that balance fire resistance and amenity and how community attitudes might change towards fire risk standards for open space, including backyards, and their enforcement.

While enhancing buffers may come at an amenity cost to the community, the financial cost will largely be borne by the government. In contrast, increasing fire standards for buildings and open space will likely be perceived as imposing a private cost on developers and owners of homes and

other infrastructure. Hence, there may be a greater appetite for buffer enhancement. However, ignoring or delaying the improvement of built asset standards could result in increased suffering and cost in the long term, as well as the loss of options to take action to reduce those costs in the future.

One way to address uncertainty about community acceptance of proactive improvement in standards may be to provide or enable strong voluntary incentives for the adoption of higher standards. For example, having a score on a sliding scale that reflected how much residual risk was reduced as a result of exceeding the minimum standards for the BAL allocated to the property. Such information could be used by insurance companies to set premiums, prospective purchasers, and designers of new houses and renovations.

4.5 Nature conservation

Climate change has the potential to drive significant changes in the abundance and distribution of species, the composition of communities, and the structure and functioning of ecosystems. Changes are already becoming evident in some places. For example, some vegetation communities in Namadgi National Park appear to be entering a period of major ecological change as a result of changing climate and fire frequency.[41] Changes in temperature and rainfall alone can be expected to lead to significant ecological change; changes in fire regimes are likely to add to these changes. Deliberate shifts in fire regimes to manage fire risk would likely affect the nature of ecological change at specific locations and across landscapes. In the face of significant ecological change, the nature conservation challenge may need to become 'how do we steer ecological change to more desirable states', as opposed to 'how do we resist ecological change' or 'how do we return to past states'. As change progresses, current or past ecological states and conditions will become less useful in determining desirable future states. However, while significant ecological change occurs, it may be reasonable to aspire to minimise the loss of native species, maximise the number of native species in communities, maintain the health or ecological condition of ecosystems, and maintain extensive areas of native ecosystems with a diversity of communities.

[41] Hawkins, B., Seddon, J., and Courtney Jones, S. "Recovery of Fire-sensitive vegetation communities in Namadgi National Park and Tidbinbilla Nature Reserve after the 2020 Orroral Valley Bushfire." Office of Nature Conservation, ACT Environment, Planning and Sustainable Development Directorate, 2024.

Translating general aspirations like these into specific future conservation objectives will involve addressing multiple uncertainties and ambiguities. These include technical issues about biophysical dynamics – how much change is inevitable and how much management can influence outcomes – and societal preferences – what aspects of nature are most valued, how much active management is desirable across the landscape, how much effort (cost) is reasonable, and how nature conservation outcomes intersect with or trade-off against managing fire risk.[42] These issues will only be resolved in coming decades, as change is experienced or through better prediction, and as community preferences evolve as the context changes. This highlights the integrated nature of fire and conservation objectives and management. There would also be multiple institutional barriers to adopting new, climate-ready conservation objectives, as current objectives are embedded in multiple interacting layers of governance, long-standing research agendas, and deeply held societal conservation narratives.

It also highlights that it is not straightforward to decide how success for nature conservation might be framed and assessed in the medium and long term. As such, evaluating how specific proposed changes in fire management might contribute to or hinder conservation success is challenging. Some current general principles are likely to continue to be useful. A diversity of fire regimes (intensity, season, time since fire, including some older post-fire age classes) is likely to provide habitat for a greater number of species than a landscape with lower diversity. This would provide functional diversity across the landscape. Other principles may need to be reevaluated. For example, increasing the frequency of fires may lead to greater ecological change and the exclusion of some species, but at some point, it is also likely to reduce the intensity of fires, which may be desirable if climate change is driving a greater occurrence of very intense fires. In this case, accelerating ecological change along a specific trajectory may be effective and justified. Establishing communities that are adapted to higher fire frequencies and that support lower intensity fire may result in more resilient ecosystems and less fire risk in the long term. However, the conditions under which this outcome could be achieved require further investigation across a range of ecosystems and is currently a key knowledge gap.

[42] Clement, S., Garmestani, A., Beckwith, J.A. and Cannon, P.J., "To burn or not to burn: governance of wildfires in Australia." *Ecology and society*, *29*(1), (2010).

Changes in climate and fire regimes are expected to lead to turnover of species within communities, and transitions from one community type to another. If species are lost from a location faster than new species colonise, then there may be a case for facilitating the establishment of functionally similar species that are better adapted to fire or future climates, either from nearby communities or outside the region. Such actions would require new skills and knowledge, and have significant ecological risks, and social and cultural risks, especially for Ngunnawal people. Where increased fire frequency is affecting water quality, it may also be desirable to strategically shape the nature of vegetation transitions to reduce ash and sediment transport. Similarly, direct interventions may be warranted in some situations where fauna species are unable to adapt to changes in vegetation. Although not done in this study, the uncertainties and issues associated with such species-level interventions could be addressed with an adaptation pathway approach.

In a landscape with more fire, it may be necessary to take additional actions to minimise the impact on some fire sensitive communities, such as some sphagnum bog, Alpine ash, and Mountain plum pine, and to maintain some areas of older post-fire age classed habitat within other communities. However, intensive measures that are likely to be ongoing, will need to be continually evaluated for feasibility and their impact on other values such as broader 'wilderness' values.

4.6 Reducing future risk

The ACT has a range of strategies in place to reduce bushfire risks, specifically including managing to reduce the incidence and intensity of bushfire in the landscape, establishing and managing buffers around assets, and ensuring infrastructure and open space are designed and managed to set standards. In general, these are to national best practice standards; they are effective and have been reviewed and improved after significant fire events in recent decades. These strategies align with themes 2 and 3, and many of the future actions identified in this analysis are similar in nature to existing activities. The current strategies reduce risk to an extent that is reasonable and feasible in the current fire and social context, with most of the 'easy' risk mitigation actions already being done. This analysis explores options in a future where the context has changed, and there is a need and desire for significant 'step' changes in various areas where further reductions in risk might be possible. The climate-ready objectives make the biophysical aspects of this changed context explicit, recognising the inevitability (in the scenario considered) of increase in the

occurrence of bushfire in the landscape and bushfires intersecting with valued assets during more frequent extreme fire weather.

Given past and current efforts to reduce fire risk, none of the future changes canvassed in this analysis will be easy; there will be many barriers, including unknown practicality/effectiveness and acceptability/trade-offs with other values. The intent of the analysis is not to prescribe any of the long-term changes that are described; rather, it is to explore what would be required, over time, to make them available as options to future decision-makers.

The future management and policy changes outlined across the climate-ready objectives are complementary. To increase the robustness of planning for future fire conditions, it will be important to create options for a variety of strategies enhancing risk management, specifically, seeking to reduce the intensity and spread of landscape-scale fire and increase the protection of assets from more frequent fires. Currently, multiple strategies are required to provide a cumulative reduction in risk, and this is likely to continue to be the case. Further, while some future actions may currently appear to be easier, more effective, or more acceptable, it is important to recognise that the physical and social context will change, and there are significant uncertainties associated with all the measures identified in this analysis. It is also likely that new strategies that may be more effective or desirable will emerge over time; the pathways developed here are intended to help stimulate innovation and create options for additional strategies.

Interstate and Commonwealth policies and legislation may shape the broader institutional context in the ACT, potentially shaping the ACT's ability to implement future management and policy actions and achieve the climate-ready objectives. Continued partnership with other jurisdictions may become increasingly important, in the development and implementation of strategies, and also the sharing of information, expertise and experiences.

Glossary

Anticipation: Anticipation is about intentionally and strategically considering long-term future trajectories of change to inform present-day decision-making and examining uncertainty, ambiguity and assumptions. Anticipation is considered a prerequisite for thinking about climate change adaptation, and is central to supporting resilience.[43]

Asset protection zones (APZ): are areas zoned specifically to enable management of fuel loads around a building or structure; they are a type of buffer.

Buffer: in this report, buffer is used to refer to an area of land on which fuels and other vegetation are managed to provide protection to surrounding lands and assets by reducing the intensity and spread of fire, enabling suppression and reducing the production of embers.

Fire: In this report, fire is used broadly to refer to fire in the landscape from a combination of prescribed burns, managed bushfires, and uncontrolled bushfires. (See also **Managed bushfire, Prescribed burn** and **Uncontrolled bushfire).**

Fire conditions: Fire conditions refers to the interaction of ACT landscape and weather.

Fire frequency: A general term referring to the recurrence of fire in a given area over time.

Fire intensity: The rate of energy release per unit length of fire front usually expressed in kilowatts per metre (Kw/m) (AFAC).[44]

Fire regime: The history of fire in a particular vegetation type or area, including the frequency, intensity, duration and season of burning. It may also include proposals for the use of fire in a given area. (AFAC). (See also **Fire frequency, Fire intensity, Fire season)**

Fire risk: In this report, fire risk refers to the combination of the likelihood and consequences of fire.

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[43] Boyd, E., Nykvist, B., Borgström, S. and Stacewicz, I.A. "Anticipatory governance for social-ecological resilience." *Ambio,* 44, (2015): 149-161.

[44] AFAC. Bushfire Glossary. Australasian Fire and Emergency Service Authorities Limited (AFAC). 36pp., East Melbourne, 2012.

Fire season: The period during which bushfires are likely to occur, spread and do sufficient damage to warrant organised fire control (AFAC).

Fire weather: Weather conditions which influence fire ignition, behaviour, and suppression (AFAC).

Fuel: Any material such as grass, leaf litter and live vegetation which can be ignited and sustains a fire. Fuel is usually measured in tonnes per hectare (AFAC).

Fuel load: The oven dry weight of fuel per unit area. Commonly expressed as tonnes per hectare (AFAC).

Hazard reduction: (also fuel management) Modification of fuels by prescribed burning, or other means (AFAC).

Managed bushfire: Fires that are of unplanned origin (i.e. bushfires) that have been controlled and are managed to achieve desired landscape fire outcomes, rather than being extinguished as quickly as possible.

Maladaptation: Maladaptation, in this context, refers to actions that might be taken to address one climate change issues, such as immediate or near-term climate impacts, but which inadvertently increase vulnerability by increasing future exposure to higher levels of climate change or reducing options for adapting to those impacts.

Prescribed burn: The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity, and rate of spread required to attain planned resource management objectives (AFAC).

Risk: The exposure to the possibility of such things as economic or financial loss or gain, physical damage, injury or delay, as a consequence of pursuing a particular course of action. The concept of risk has two elements, i.e. the likelihood of something happening and the consequences if it happens.

Risk appetite: Risk appetite is the amount of risk that an entity is willing to accept or retain in order to achieve its objectives. Determining and articulating an entity's risk appetite assists entities to make better choices by considering risk more effectively in decision-making.

Uncontrolled bushfire: In this report, bushfire that has not been successfully controlled and has the potential to cause loss or damage to physical or built assets or cultural values.

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