NSW GOVERNMENT | Natural Resources Commission

DRAFT REPORT

Active and adaptive cypress management in the Brigalow and Nandewar State Conservation Areas

June 2014

Enquiries

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List of acronyms

ADS40	Digital Image Acquisition System
Cth	Commonwealth (Australian Government)
LiDAR	Light Detection and Ranging
NRC	Natural Resources Commission
NSW	New South Wales
SLATS	Statewide Landcover and Trees Study
SPOT 5	Statellite Pour l'Observation de la Terre (Satellite for observation of Earth)

Document No. D14/0463

ISBN: 978 1 921050 94 7

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Part III - Attachments

Executive summary

The NSW Premier asked the Natural Resources Commission (NRC) to investigate active and adaptive management of white cypress pine forests in the State Conservation Areas of the Brigalow and Nandewar Community Conservation Areas.

The Brigalow and Nandewar Community Conservation Area covers an area of about 7.9 million hectares in the north west of NSW and includes the regional centres of Moree, Narrabri, Tamworth, Gunnedah and Dubbo. Of this area, 90 percent (or 7.1 million hectares) is private land. In comparison, the State Conservation Areas represent 2.5 percent (or 195,095 hectares) of the land in the assessment area.

The National Parks, State Conservation Areas, and indeed State Forests, of the region are ecologically and culturally significant. The State Conservation Areas provide native vegetation habitat for threatened species and support Aboriginal values, recreation, apiary and mineral and petroleum exploration and extraction. However, visitor numbers to State Conservation Areas are low and the area available for forestry in the region has declined over time. The towns of Baradine and Gwabegar are heavily dependent on white cypress pine forestry and are sensitive to changes in this sector.

In pre-European times, it is likely that significant areas of the forests were managed by regular intentional burning by Aboriginal people. Since European settlement in the 1800's fire frequency has decreased; this combined with forestry activities and other disturbances has resulted in the number and extent of white cypress pine increasing in the State Conservation Areas.

Large areas of dense white cypress pine impact on environmental values. For example, they reduce mosaics of native vegetation types and structures in the landscape which provide a range of habitats and support soil health. Under NSW native vegetation regulations, white cypress pine is recognised as an invasive native species, and can be cleared or thinned on private and leasehold land (up to 90 percent of NSW) to maintain or improve environmental outcomes.

Based on its analysis, including analysing digital aerial imagery, the NRC has concluded that approximately 70 percent of the State Conservation Area is not impacted by large areas of dense white cypress pine. However, 30 percent of the area (approximately 57,000 hectares) contains large areas of relatively dense white cypress pine that are potentially impacting on environmental values. Recent scientific studies suggest that the extent and density of white cypress pine in the Pilliga region is likely to further increase in the future.

The NRC has found that active management interventions such as ecological thinning and targeted grazing, in combination with controlled burning and pest management, can maintain and enhance environmental outcomes of these forests. The environmental benefits include:

- maintaining and enhancing landscape heterogeneity
- promoting regeneration and growth of trees (especially eucalypts) and shrubs
- improving habitat for fauna and promoting viable populations of native fauna and flora species (especially of rare and threatened species)
- promoting diversity by controlling dominant species (such as weeds)
- maintaining and enhancing ground cover and soil health.

Ecologically, white cypress pine forests are very different from forests in coastal regions, and management interventions that are likely to benefit these unique forests are not necessarily appropriate for other forest types.

Consistent with the principles of adaptive management, the NRC recommends that active management be applied initially in the four priority State Conservation Areas (Pilliga, Pilliga West, Goonoo and Trinkey) which contain larger patches of dense white cypress pine. In areas with less dense cypress the management objective should be to maintain or prevent further degradation of existing environmental values.

Interventions which are carried out for the primary purpose of achieving environmental benefits and are consistent with the principles of ecologically sustainable development comply with the *National Parks and Wildlife Act 1974* (NSW).

In undertaking active management to enhance environmental outcomes, the NSW Government should seek secondary commercial benefits, as appropriate, to off-set costs, improve long-term sustainability of the program and deliver social and economic benefits. The NRC has obtained legal advice that by-products generated from active management, such as ecological thinning, could be used for secondary commercial purposes, provided interventions have been carried out for the primary purpose of delivering positive environmental outcomes.

Based on the NRC's modelled scenarios for the four priority State Conservation Areas over a seven year period, ecological thinning in an adaptive management framework, could generate thinning residues of 1,000 m^3 to 14,000 m^3 per annum of saw logs and 1,800m^3 to 23,000 m^3 per annum of landscaping products. In practice, it is likely that ecological thinning will only target specific areas of concern within these State Conservation Areas, thus reducing the extent in area and volume of timber residues potentially available for commercial purposes.

The NRC proposes that a mix of cost recovery mechanisms be utilised to at least partially recover the costs of undertaking active management, including a 'goods for services' approach which is commonly used in the United States. Under such a scheme the ecological thinning activity could be outsourced and commercial operators would be able to sell the thinning by-products in exchange for providing the environmental service. Based on the modelled scenarios, the net cost to Government would be $40 per hectare to $330 per hectare, depending on the amount of cost incurred by parties engaged to undertake the services.

In addition to providing significant long-term ecological benefits, such a scheme is likely to provide benefits to local timber businesses, households and families, particularly in the communities of Baradine and Gwabegar.

Part I

1 Recommendations

1 Actively manage the State Conservation Areas

The NRC recommends that:

1(a) interventions such as ecological thinning and targeted grazing be implemented in combination with existing management practices (prescribed fire and pest management) to maintain and improve environmental outcomes including encouraging regeneration of eucalypts; improving habitat for animals; improving groundcover and soil health; and reducing risk of intense wild fires. Any ecological thinning should be guided by the principles set out in **Table 24.**

2 Implement interventions in line with principles of adaptive management

The NRC recommends that:

2(a) the NSW Government develop and implement an Adaptive Management Plan for the Brigalow and Nandewar State Conservation Areas, based on the adaptive management framework set out in **Table 7**

2(b) monitoring, evaluation and reporting in the Adaptive Management Plan should capitalise on the cost efficiency opportunities provided by spatial data technologies and build on the spatial analysis undertaken by the NRC for this review.

3 Develop plans of management for State Conservation Areas

The NRC recommends that:

3(a) consistent with the overarching Adaptive Management Plan, new or revised plans of management for State Conservation Areas should be developed. It is proposed that the 23 State Conservation Areas in the assessment region be consolidated into a smaller number of functional groups to streamline planning and administration processes. Any such groupings should be subject to consultation with relevant National Parks and Wildlife Regional Advisory Committees

3(b) the Office of Environment and Heritage prioritise the development of plans of management for the four State Conservation Areas identified as being priority areas for active management (Goonoo, Pilliga, Pilliga West and Trinkey State Conservation Areas).

4 Seek cost recovery and sharing opportunities to implement active and adaptive management

The NRC recommends that:

4(a) where active and adaptive management is undertaken to enhance environmental outcomes, the NSW Government seek secondary commercial benefits, as appropriate to off-set costs, improve long-term sustainability of the program and deliver social and economic benefits to local industries and communities

4(b) the NSW Government explore the use of a 'goods for services' scheme as an effective means of cost recovery when implementing an ecological thinning program.

5 Amend legislation to facilitate active and adaptive management

The NRC recommends that:

5(a) the Adaptive Management Plan for the State Conservation Areas be a legislative requirement, to be completed by the Office of Environment and Heritage within a specified time and approved by the Minister for the Environment, and include specific, measurable and spatially explicit management targets

5(b) approval of plans of management for each State Conservation Area be devolved to relevant National Parks and Wildlife Service regional managers

5(c) the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) and existing State Conservation Area plans of management be amended to expressly provide for the commercial use of residues from ecological thinning

5 (d) the *Protection of Environment Operations (General) Regulation 2009* (NSW) be amended to allow the use of native forest bio-material obtained from trees cleared in accordance with the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) to be used for electricity generation

5(e) the NSW Government seek Australian Government amendments to the *Renewable Energy (Electricity) Regulations 2001* (Cth) to recognise the use of ecological thinnings residues under the Renewable Energy Target.

6 Review governance arrangements in the State Conservation Areas

The NRC recommends that:

6(a) current governance arrangements be revised to reduce the duplication of advisory bodies. In particular, the NSW Government should consider using the National Parks and Wildlife Regional Advisory Committees, with membership expanded to include adaptive management expertise, to provide advice during the development of the Adaptive Management Plan

6(b) accountability for the Adaptive Management Plan be provided through the Office of Environment and Heritage's internal accountability systems, and supported by an independent review process

6(c) a Regional Officers Working Group be established to facilitate cross-tenure operational collaboration between land managers and to consider land management that is occurring on other land tenures within the Community Conservation Area.

2 Review findings

In the Terms of Reference, the Premier asked the NRC to:

- assess the potential environmental and socio-economic impacts and benefits of undertaking **active and adaptive management** in the Brigalow and Nandewar State Conservation Areas, consistent with the objects of the *National Parks and Wildlife Act 1974* (NSW), specifically the principles of ecological sustainable development
- identify options for developing an active and adaptive management program for cypress forests to maintain and enhance environmental values in these State Conservation Areas.

This section summarises the NRC's key findings of its review. Full details of the review, including references and evidence to support these findings, are found in the following sections.

Active management can be defined as deliberate interventions in the landscape to meet a specified objective. Many conservation practitioners and researchers accept that direct human interventions may be necessary in some circumstances to achieve desired conservation goals and objectives.

Adaptive management is a formal framework for inquiry that helps managers ensure that interventions are contributing to stated management objectives, and learn about what interventions work best to improve their management strategies over time. Adaptive management is strongly advocated as a necessary means to manage the complexity and uncertainty inherent in environmental and natural resources management.

Active interventions are most effective when implemented as part of an adaptive management process. In this report **active and adaptive management** refers to the deliberate application of a range of management interventions within a formal framework for evaluation, learning and adapting over time.

The State Conservation Areas (also known as the Community Conservation Area Zone 3) account for around 2.5 percent of the Brigalow and Nandewar Community Conservation Area. **Figure 1** presents a map of the assessment area and **Figure 2** provides a map of the State Conservation Areas.

Along with other public land tenures within the Community Conservation Area, the State Conservation Areas provide critical areas of native vegetation within a cleared landscape, including habitat for threatened species. These areas are managed for conservation, recreation and cultural values, and are also used for apiary, and mineral and petroleum exploration and extraction.

The review focuses on the white cypress pine (*Callitris glaucophylla*) forests of the Brigalow and Nandewar State Conservation Areas. Ecologically, white cypress pine forests are very different from forests in coastal regions, and management interventions that are likely to benefit these unique forests are not necessarily appropriate for other forest types.

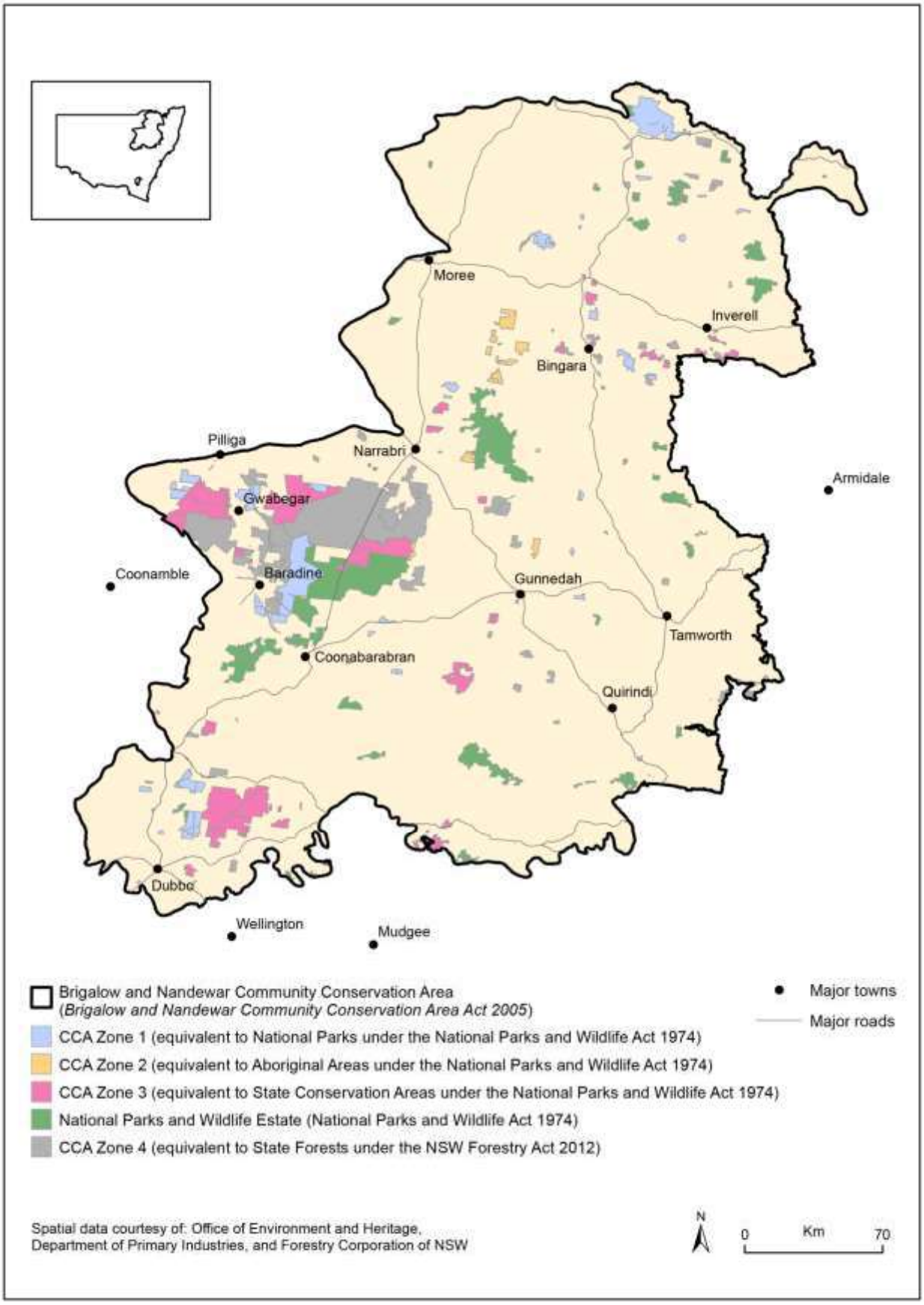

Figure 1: Map of the Brigalow and Nandewar State Conservation Areas (Zone 3 within the Brigalow and Nandewar Community Conservation Area)

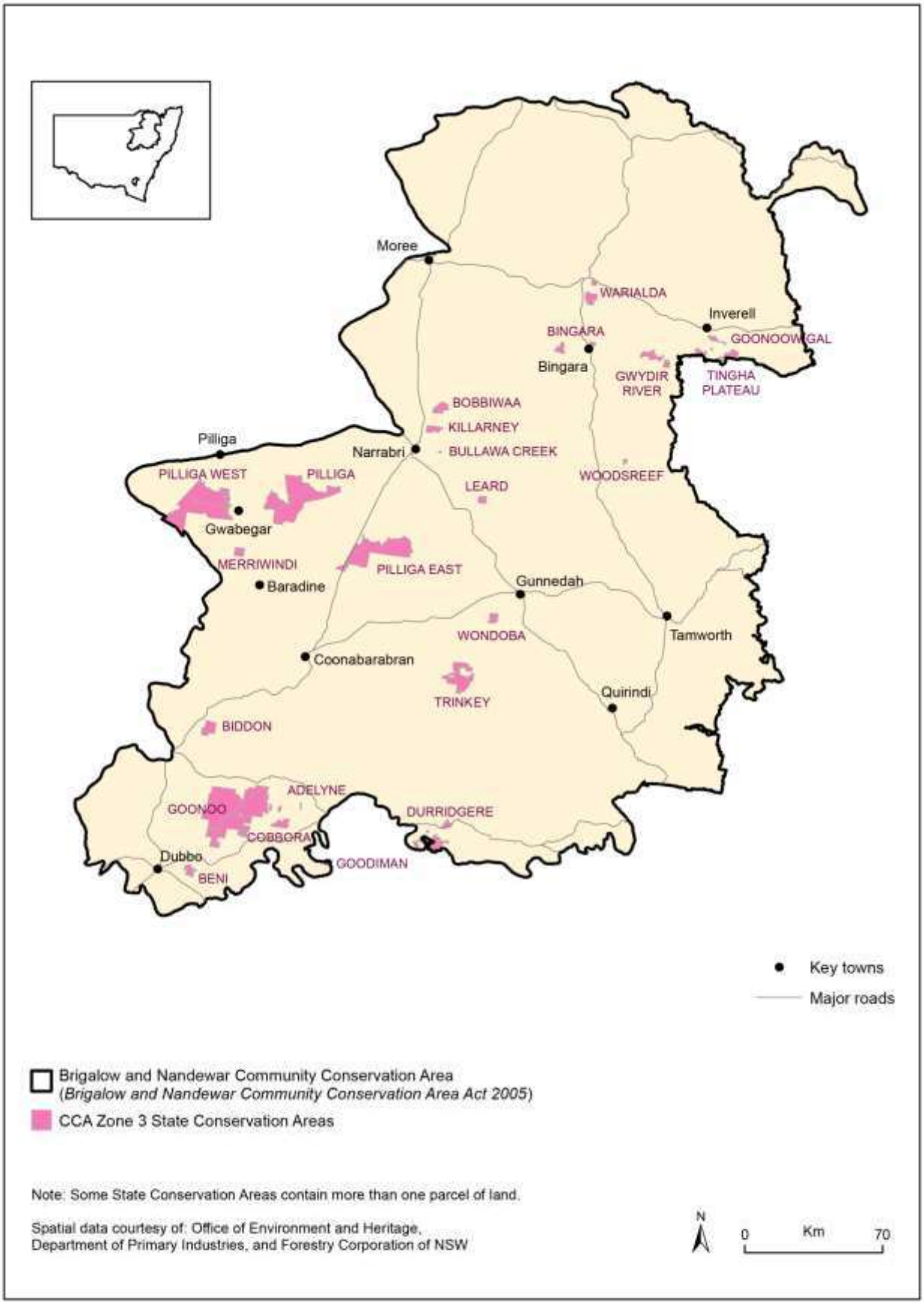

Figure 2: Map of the Brigalow and Nandewar State Conservation Areas

2.1 Past white cypress pine management

The State Conservation Areas lie within a heavily modified landscape, and have been subject to varied historical management practices. Prior to European settlement, Aboriginal fire management is likely to have shaped these forests. European settlement then brought about intensive agricultural development in the region and over 140 years of management for white cypress pine timber in the forests that are now State Conservation Areas.

Although there is some debate about the exact structure and composition of the pre-European landscape, there is a general consensus that, since European settlement, many formerly open grassy white cypress pine woodlands have transitioned to denser forest or scrub formations, with an increase in white cypress pine-dominated vegetation communities.

Small patches of dense white cypress pine provide habitat for native flora and fauna within a landscape mosaic. However, large areas of dense white cypress pine that are uniform in height are less likely to support ecological values compared to vegetation that contains a mosaic of different native plants and shrubs and trees with varying heights. In particular, a shift from eucalypt to white cypress pine-dominated vegetation communities has had significant effects on the fauna that rely on eucalypts.

2.2 Current forest condition and potential future trajectories

The NRC undertook spatial analysis to understand the extent, distribution and density of white cypress pine together with forest structure and floristic diversity in the State Conservation Areas.

The NRC found over 57,000 hectares (or 30 percent) of State Conservation Areas contain large areas of relatively dense white cypress pine. The NRC has identified these as being areas of management concern for State Conservation Area managers. In particular, there are four State Conservation Areas (Pilliga, Pilliga West, Goonoo and Trinkey) that have patches of dense white cypress pine covering areas greater than 500 hectares, and these have been identified as priority areas for intervention.

However, over half of the total area of State Conservation Areas contains little or no white cypress pine, or low canopy densities. The NRC estimates that around 70 percent of the total area of State Conservation Areas could be considered to be in acceptable condition in respect of dense white cypress pine.

The extent of dense white cypress pine stands could expand or contract under the influence of different natural disturbances and management activities. However, recent studies suggest that under future climate change predictions, the extent and density of white cypress pine is likely to expand.

Dense stands of bulloak (Allocasuarina luehmannii) also appear to be an emerging management issue in State Conservation Areas.

2.3 Actively managing State Conservation Areas

The NRC believes white cypress pine should be actively managed using ecological thinning, targeted grazing and prescribed fire to maintain and enhance environmental outcomes. These interventions can increase landscape heterogeneity, promote groundcover and encourage regeneration and growth of trees that improve ecological habitat.

The primary purpose of these management interventions is to manipulate vegetation structure and composition in dense areas of white cypress pine. In proposing these interventions, the NRC also recognises that vegetation is one of the few biophysical elements that land managers can practically manage to maintain or enhance desired ecological outcomes.

The proposed management interventions are consistent with practices already occurring on private land. Currently, white cypress pine can be thinned or cleared with certain prescriptions to maintain and improve environmental outcomes on private or leasehold land (around 90 percent of NSW).

Table 1 sets out the interventions that should be implemented to actively manage the State Conservation Areas in order to meet specific objectives. Some of these interventions are already being used in the State Conservation Areas, while others represent new management tools for these areas.

State Conservation Area managers should be given the flexibility to choose an appropriate intervention based on the unique context of a particular location and the comparative cost effectiveness of available options. In addition, they need to consider how these potential interventions can be combined or sequenced to deliver optimal ecological outcomes.

The NRC considers that the primary risks associated with the proposed management interventions stem from these interventions being implemented at an inappropriate intensity, frequency and/or location, all of which could lead to diminished heterogeneity in the landscape.

Table 1: Key active management interventions to maintain and enhance environmental outcomes

Intervention	Primary purpose	Ecological benefits	Previous or current application
Ecological thinning	▪ Manipulate vegetation structure and composition	▪ Increase landscape heterogeneity ▪ Promote regeneration and growth of trees (especially eucalypts) and shrubs ▪ Improve habitat for fauna ▪ Promote viable populations of native fauna and flora species (especially of rare and threatened species)	▪ Office of Environment and Heritage is undertaking an ecological thinning trial in NSW river red gum forests ▪ Landholders can clear or thin white cypress pine on private or leasehold land to maintain or improve environmental outcomes under native vegetation regulations ▪ The Department of Primary Industries' forest research team is also currently undertaking research on the effects of early thinning on biodiversity in river red gum state forests
Targeted grazing	▪ Manipulate vegetation structure and composition ▪ Reduce fuel loads ▪ Reduce impact of weeds	▪ Promote diversity by controlling dominant species and habitat for fauna (grazing likely to be used only in limited circumstances and on a small-scale)	▪ Already applied in a limited number of NSW National Parks ▪ NSW Office of Environment and Heritage is currently undertaking grazing trials on south-western cypress reserves and river red gum reserves to evaluate potential environmental, social and economic benefits and risks
Prescribed fire	▪ Manipulate vegetation structure and composition ▪ Reduce fuel loads	▪ Increase landscape heterogeneity ▪ Promote regeneration and growth of trees (especially eucalypts) and shrubs ▪ Reduce risk of extensive and damaging fires	▪ Already applied in Brigalow and Nandewar State Conservation Areas, primarily to protect properties and other assets
Pest and weed control	▪ Reduce impact of pests and weeds	▪ Promote viable populations of native fauna and flora species ▪ Improve groundcover ▪ Improve soil health	▪ Already applied in Brigalow and Nandewar State Conservation Areas

2.4 Adaptively managing State Conservation Areas

Plans of management guide management activities in State Conservation Areas. These plans are legal documents that explain how a park reserve will be managed, and are required for all reserves under the *National Parks and Wildlife Act 1974* (NSW). To date, the Office of Environment and Heritage has completed final plans of management for three of the 23 State Conservation Areas.

Current plans of management allow for management interventions to control pests and weeds and to manage wildfires, but do not apply these interventions within a best practice adaptive management framework. This means management assumptions are not being fully documented and tested, and opportunities for learning and improving current management approaches are being missed.

In addition, it is likely to be more cost-effective to undertake preventative management interventions in at-risk areas now, rather than trying to restore forest areas after they have degraded and plants and animals have become endangered.

The NRC recommends that the NSW Government facilitate best practice active and adaptive management for the Brigalow and Nandewar State Conservation Areas by developing and implementing an Adaptive Management Plan. Consistent with this plan, new or revised active and adaptive plans of management for the State Conservation Area should be developed as a priority.

To streamline the planning and administration process associated with developing and implementing plans of management, it is proposed that the 23 State Conservation Areas in the Brigalow and Nandewar region be consolidated into a smaller number of functional groups, and that the approval of plans of management for each of these be devolved to relevant National Parks and Wildlife Service regional managers.

2.5 Costs and potential cost recovery

For all management interventions there will be administrative and operational costs incurred by the NSW Government. The overall cost will depend on the location and extent of land being actively and adaptively managed, and on the chosen intervention regime.

The NRC has investigated the potential costs to the NSW Government associated with ecological thinning in the State Conservation Areas using a range of options and cost recovery scenarios.

The NRC estimates it would cost between approximately $320 and nearly $575 per hectare to address all potential areas of management concern over a seven year period, using a program that includes periodic outcomes-based performance audits. In practice, it is likely that State Conservation Area managers will focus on even more targeted priority areas for interventions, thus reducing the extent and cost of the management program.

Revenue received from the commercial use of ecological thinning residues by the timber industry could offset overall program costs. Cost recovery via this avenue is anticipated to be between 30 and 40 percent of the total program costs.

Alternatively, under a 'goods for services' scheme forest products could be traded for services (in this case ecological thinning), in the form of forest restoration projects. Projects could involve the removal of trees and biomass for improved forest health. The United States has been implementing a similar scheme with contracts and agreements since 2003.

Under this scheme all direct costs and commercial benefits from ecological thinning could be incurred and accrued by parties undertaking ecological thinning. Overall program costs could be reduced to between $40 and $330 per hectare under such a scheme, depending on the costs incurred by parties to undertake the services and the quantity and value of the by-products produced.

2.6 Implications for local communities

Active and adaptive management in State Conservation Areas has the potential to provide socio-economic benefits to local communities. The level of benefits arising from these management actions will depend on the extent, location and commercial opportunities that arise from these interventions.

If commercial use of thinning by-products is permitted, ecological thinning will provide an economic benefit to local timber businesses, households and families, particularly in the communities of Baradine and Gwabegar. Any improvements in household income, expenditure and employment are likely to lead to positive changes to the resilience of Baradine and Gwabegar, given these towns are highly sensitive to changes in the timber industry and have a low capacity to adapt to change. Improvements in resilience may mean that Baradine and Gwabegar avoid further social decline and maintain current workforce capabilities in the timber industry and connection to the forests.

The relatively robust, diverse regional economy and the small size of change anticipated from active and adaptive management mean these benefits are likely to be insignificant at a wider regional level.

2.7 Implementing active and adaptive management

2.7.1 Legislative requirements and proposed amendments

Active management which is carried out for the primary purpose of achieving environmental benefits, and is consistent with the principles of ecological sustainable development, will comply with the *National Parks and Wildlife Act 1974* (NSW).

However, to reduce the risk of legal challenge and provide greater certainty around the commercial utilisation of ecological thinnings, the NRC recommends the following amendments to:

- the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) to expressly provide for ecological thinning in Zone 3 where it delivers secondary economic benefits providing the primary ecological test has been met
- existing draft and final plans of management, including permitting ecological thinning, targeted grazing and/or prescribed fire interventions (as required).

The *Protection of Environment Operations (General) Regulation 2009* (NSW) should also be amended to allow native forest bio-material obtained from trees cleared in accordance with the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) to be used for electricity generation.

The Australian Government's failure to recognise the use of native forest-derived residues under the Renewable Energy Target is also a barrier to finding commercial opportunities for ecological thinning residues. It is therefore recommended that the NSW Government seek Australian Government amendments to the *Renewable Energy (Electricity) Regulations 2001* (Cth) to recognise the use of ecological thinning residues obtained from State Conservation Areas under the Target.

2.7.2 Governance and accountability

The NRC recommends that accountability mechanisms for active and adaptive management in the State Conservation Areas should be provided through the Office of Environment and Heritage's internal accountability systems.

As an additional accountability mechanism, the development and implementation of the Adaptive Management Plan should be subject to an independent review process. This may take the form of a review by an independent body or review panel with appropriate skills and expertise in active and adaptive management. The Minister should also seek advice from an independent reviewer before approving the overarching Adaptive Management Plan.

The NRC has developed a revised governance framework for the State Conservation Areas. In doing so, the NRC identified that current governance arrangements should be revised to reduce duplication of advisory bodies. In particular, the NSW Government should consider using the National Parks and Wildlife Regional Advisory Committees, with membership expanded to include additional adaptive management expertise, to provide advice during the development of the Adaptive Management Plan.

The NRC recommends that the Adaptive Management Plan be a legislative requirement, to be completed by the Office of Environment and Heritage within a specified time and approved by the Minister for the Environment.

The NRC also proposes that a Regional Officers Working Group be established to facilitate cross-tenure collaboration between land managers at the operational scale. The structure and governance arrangements for this group would be non-prescriptive and flexibile, to capitalise on goodwill and co-operative relationships that occur at this level in the region.

2.7.3 Evaluation performance and driving improvement

The Adaptive Management Plan should be supported by a monitoring and research framework, that capitalises on the cost efficiency and analytical opportunities provided by spatial data technologies and builds on the spatial analysis undertaken by the NRC within this review.

Part II

3 Overview of the review

This chapter outlines the Natural Resources Commission's (NRC's) scope as per the Terms of Reference. It provides the analytical framework underpinning the review, and explains the evidence and stakeholder consultation that has informed the NRC's analysis.

3.1 Terms of Reference

In a Terms of Reference (provided in full in **Attachment 1**), the Premier has asked the NRC to:

- assess the potential environmental and socio-economic impacts and benefits of undertaking adaptive and active management in the Brigalow and Nandewar State Conservation Areas, consistent with the objects of the *National Parks and Wildlife Act 1974* (NSW), specifically the principles of ecological sustainable development
- identify options for developing an adaptive and active management program for cypress forests to maintain and enhance environmental values in these State Conservation Areas.

The Terms of Reference state that the NRC's review should consider, in the context of ecological sustainable development, the:

- current ecological value of the forest and future values under different adaptive and active management options and processes
- current social and economic impacts and benefits of the forest and future social and economic values under different adaptive and active management options and processes
- commercial opportunities derived from adaptively managing these forests, including costs and benefits of silvicultural or thinning programs
- appropriate mechanisms that could ensure accountability, track performance and facilitate adaptive management
- relevant legislation, agreements and management plans such as the NSW *Brigalow and Nandewar Community Conservation Area Act 2005*, Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the *Brigalow and Nandewar Integrated Forests Operations Agreement*.

Chapter 4 provides some background information about the State Conservation Areas, which are listed in full in **Attachment 2**. A separate booklet providing an overview of each State Conservation Area has also been developed, and is available on the NRC website.[1]

Active and adaptive management is explained further in **Chapter 5**. Under the objects of the *National Parks and Wildlife Act 1974* (NSW), any active and adaptive management proposed in the State Conservation Areas must be designed with the primary objective of delivering improved conservation outcomes for nature and objects, places or features (including biological diversity) of cultural value within the landscape. Therefore, any opportunities for cost recovery or other commercial benefits must be a secondary consideration to the promotion of improved ecological, cultural and recreational outcomes.

[1] Booklet available online at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx

3.2 Managing white cypress pine forests

The Terms of Reference refer to developing an active and adaptive management program for cypress forests. In this review, the term 'cypress forests' refers to all vegetation communities[2] dominated by or associated with white cypress pine (*Callitris glaucophylla*[3]), including woodland vegetation communities.

White cypress pine generally occurs in vegetation communities alongside eucalypts, as either a dominant, co-dominant or sub-dominant species (Forestry Corporation of NSW, 1989; Lindsay, 1967). The NRC estimates that of the 90 vegetation communities (NSW Vegetation Classification and Assessment) associated with the Brigalow and Nandewar State Conservation Areas, 35 contain white cypress pine as either the dominant or sub-dominant species (Hunter, 2008a, 2008b, 2008c, 2010).

All State Conservation Areas contain white cypress pine. **Chapter 7** and **Attachment 3** provide more information on the extent and distribution of white cypress pine based on data from remote sensing.

Although this review focuses on white cypress pine forests, the NRC recognises there are many other plant communities within the State Conservation Areas that are also likely to benefit from improved management approaches. Furthermore, any active and adaptive management of these areas should occur within the context of management across the broader regional landscape.

3.3 Analytical framework and lines of evidence

The analytical framework for this review is shown in **Figure 3**.

The NRC has drawn on multiple lines of evidence to meet the requirements of the Terms of Reference, including scientific literature, agency data, spatial analysis, field visits, and stakeholder submissions, knowledge and expertise.

In particular, the NRC has undertaken new spatial analysis to inform this review, including the development and use of new methodologies. Further information about the NRC's spatial analysis is provided in **Chapter 7** and **Attachment 3**.

The NRC also sought additional input and review from expert technical advisors, as listed in **Attachment 4**.

3.4 Stakeholder consultation

During this review, the NRC worked closely with key NSW agencies including the Office of Environment and Heritage (including the National Parks and Wildlife Service), the Environment Protection Authority, the Department of Primary Industries and the Forestry Corporation of NSW.

2 A collection of plant species occupying a particular area.
3 Sometimes referred to as the eastern coastal cypress (*Callitris columellaris*).

The NRC also undertook:

- a public submissions process, which generated 35 submissions (see **Attachment 5** for a list of submissions and **Attachment 6** for a summary of stakeholder feedback)[4]
- targeted consultation with relevant industry, Aboriginal, environment and community groups (see **Attachment 7** for a full list of stakeholder consultations)
- regional tours to visit State Conservation Areas and other reserve areas within the Brigalow and Nandewar region (see **Attachment 8**).

[4] Submissions available online at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx (accessed 21 December 2013).

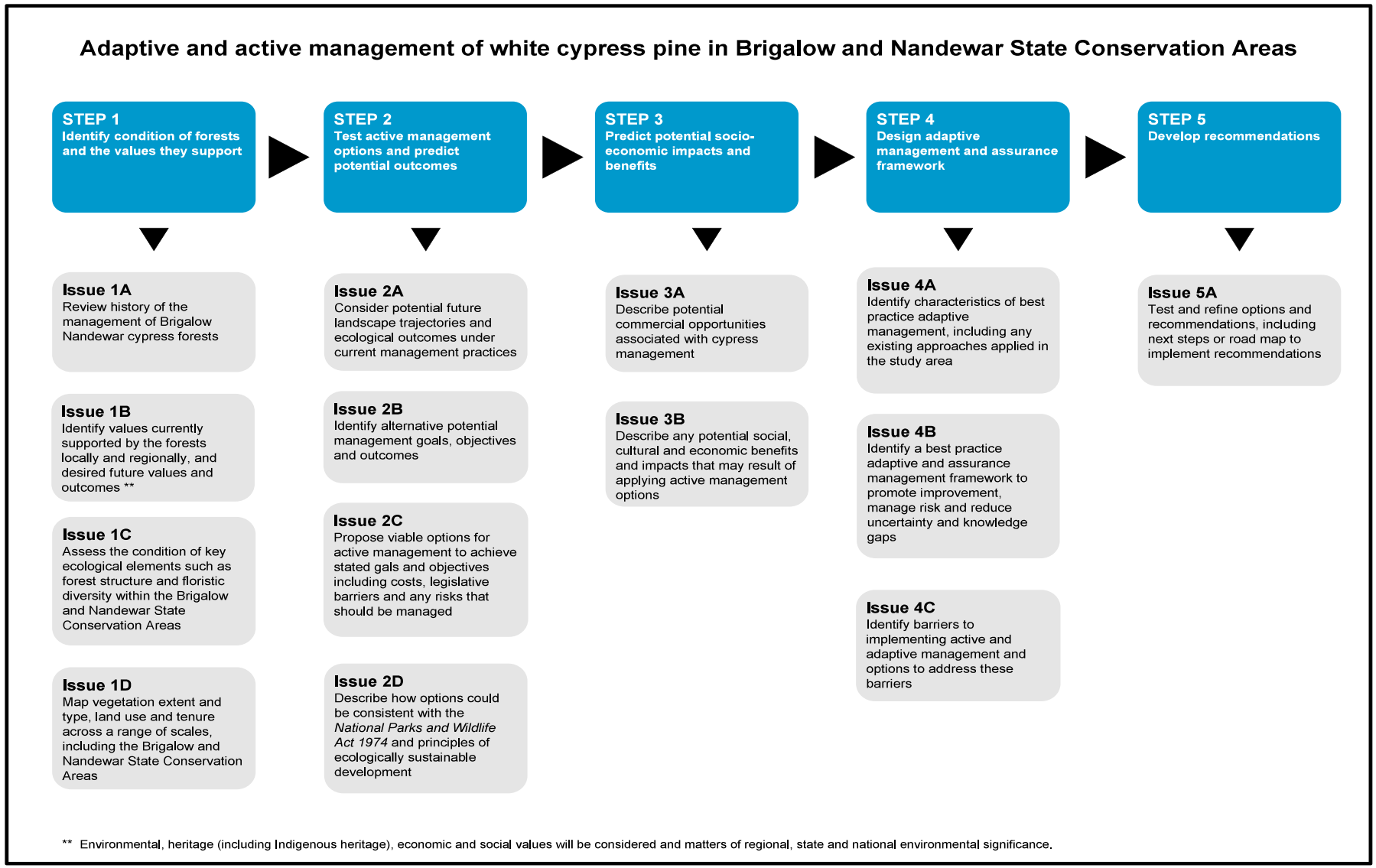

Figure 3: NRC's analytical framework

4 The Brigalow and Nandewar State Conservation Areas

Key points

KP 4.1 In 2005, the NSW Government established the Brigalow and Nandewar Community Conservation Area, which includes management zones that align with National Park, Aboriginal Area, State Conservation Area and State Forest tenures.

KP 4.2 Along with other public land tenures, the State Conservation Areas currently contribute substantial areas of native vegetation in an otherwise highly cleared landscape, providing important refugia and vegetation corridors.

KP 4.3 The State Conservation Areas support a range of ecological, social, cultural and economic values, including habitat for threatened species, Aboriginal and recreational values, apiary, and mineral and petroleum exploration and extraction.

This chapter provides background information about the Brigalow and Nandewar State Conservation Areas, including their landscape context and the ecological, social, cultural and economic values they currently support.

4.1 Establishing the Brigalow and Nandewar Community Conservation Area

In 2005, the NSW Government established the Brigalow and Nandewar Community Conservation Area under the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW). Existing reserve areas and State Forests were allocated to new management zones (see **Table 2**) to be managed in consultation with the local community for a range of specific outcomes.

Table 2: Brigalow and Nandewar Community Conservation Area

Zone	Tenure	Area (hectares)	Managed for	Legislation
1	National Park	120,810	Conservation and recreation	Managed under the *National Parks and Wildlife Act 1974* (NSW)
2	Aboriginal Area	1,152	Conservation and Aboriginal culture	
3	State Conservation Area	195,095	Conservation, recreation, and mineral and petroleum exploration and extraction	
4	State Forest	280,910	Forestry, recreation, and mineral and petroleum exploration and extraction	Managed under the *Forestry and National Park Estate Act 1998* (NSW) and *Forestry Act 1916* (NSW)

The *Brigalow and Nandewar Community Conservation Area Agreement 2009*, in place between 2009 and 2016, provides a framework for co-ordinated management of these zones.

4.2 Institutional context

Within the Brigalow and Nandewar Community Conservation Area, there are 23 State Conservation Areas (see **Figure 2** for map and **Attachment 2** for full list). As described in section 2.2.3 of the *Brigalow and Nandewar Community Conservation Area Agreement 2009*, the Brigalow and Nandewar State Conservation Areas are allocated this tenure as they:

- contain significant or representative ecosystems, landforms or natural phenomena or places of cultural significance
- provide opportunities for sustainable visitor use and enjoyment, the sustainable use of buildings and structures, or research
- provide opportunities for uses permitted under other provisions of the *National Parks and Wildlife Act 1974* (NSW), including exploration, mining and petroleum products.

The State Conservation Areas are managed by the Office of Environment and Heritage (through the National Parks and Wildlife Service) under plans of management (see **Section 5.3** for further discussion of these plans). Currently, three of the 23 State Conservation Areas have final plans of management, with a further two at the draft stage. **Attachment 2** identifies which areas currently have plans of management, as well as other plans and strategies for pest and fire management relevant to specific State Conservation Areas.

At the state scale, the *National Parks and Wildlife Act 1974* (NSW) and *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) legislate objectives and management principles for State Conservation Areas. The *Brigalow and Nandewar Community Conservation Area Agreement 2009* also sets out strategic aims for zones, and specific objectives for State Conservation Areas.

Attachment 9 sets out a full list of relevant legislation, while **Section 13.2** provides more detail about the legislative requirements for active and adaptive management in the State Conservation Areas.

4.3 Landscape context

Figure 4 shows an aerial view of the Brigalow and Nandewar Community Conservation Area within the landscape.

Freehold land accounts for 90 percent of the area within the Brigalow and Nandewar Community Conservation Area, covering approximately 7.1 million hectares out of a total 7.9 million hectares. Much of the freehold land tenure is dominated by grazing pastures (brown in **Figure 4**), while areas of irrigated cropping is found to the west of Moree (bright green areas in **Figure 4**).

In comparison, the State Conservation Areas (outlined in red in **Figure 4**) account for around 2.5 percent of land within the assessment area. The State Conservation Areas, in combination with the other Community Conservation Area Zones (1, 2 and 4) and other reserves, contain some of the largest tracts of contiguous vegetation in the assessment area (darker green in **Figure 4**).

Outside of the two significant contiguous areas of vegetation that contain Goonoo, Pilliga, Pilliga East and Pilliga West State Conservation Areas, most other reserves contain relatively small and isolated vegetation patches across the landscape.

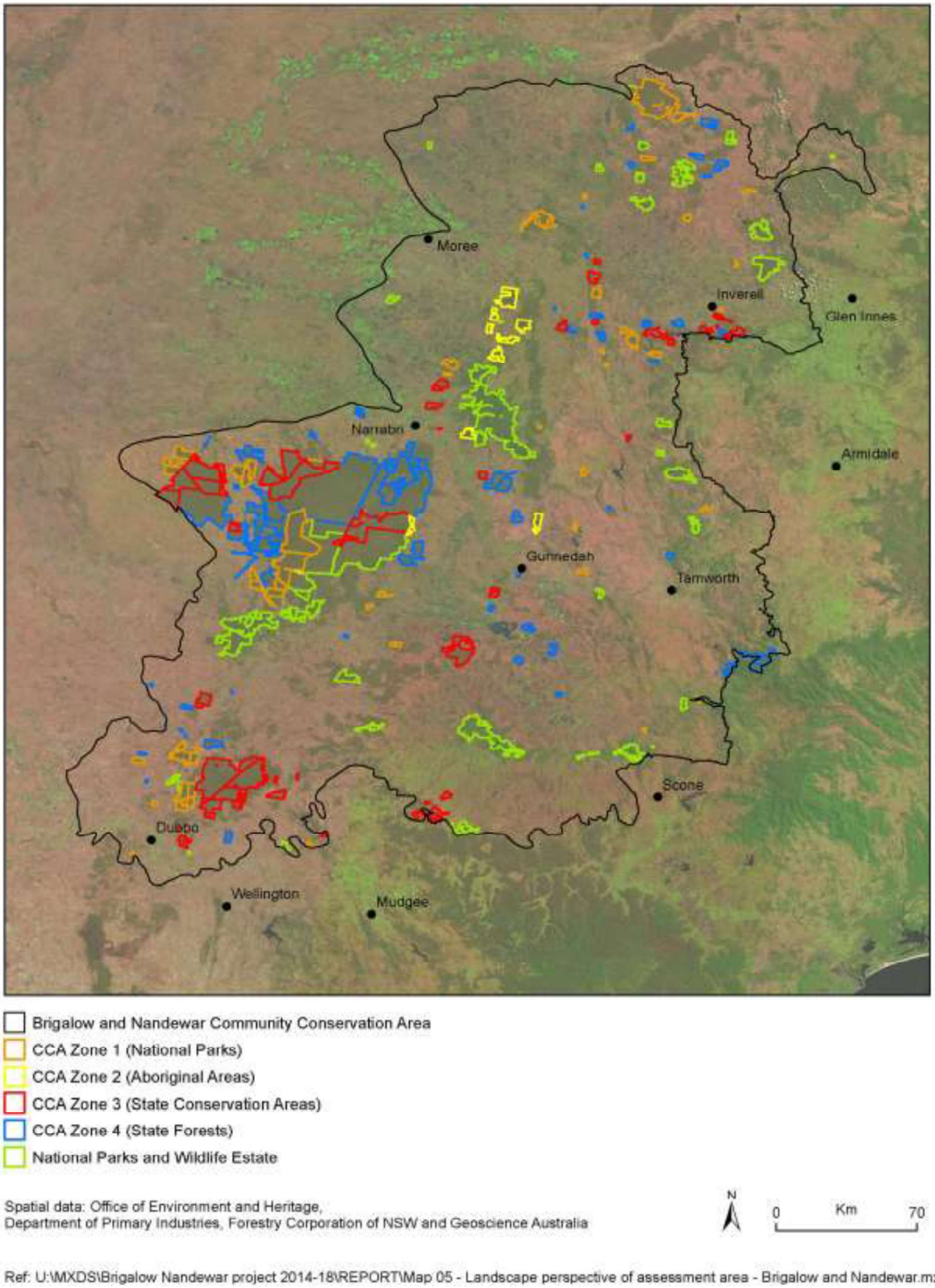

Figure 4: Landscape perspective of the assessment area

4.4 Values currently supported

The State Conservation Areas support a range of ecological, social, cultural and economic values through the provision of ecosystem services.

Ecosystem services are the benefits, both tangible (products and processes) and intangible (cultural and spiritual values), that humans gain from natural ecosystems (Costanza et al., 1997; Millennium Ecosystem Assessment, 2005). Most definitions of ecosystem services recognise the role of biodiversity and ecosystem processes in sustaining human populations and well-being (Balvanera et al., 2006; Butler & Oluoch-Kosura, 2006).

Table 3 describes some of the ecosystem services that could be provided by white cypress pine forests within the State Conservation Areas. In practice, which services are provided depends on how an area is being managed. Some provisioning services, such as biomass fuel and timber and wood products, are currently not being sought under State Conservation Area tenure.

Table 3: Ecosystem services that could be provided by white cypress pine forests within the State Conservation Areas (adapted from Millennium Ecosystem Assessment 2005; Reid 2010)

Ecosystem services	
Provisioning services *Goods that humans derive from ecosystems, for example food, fibre, timber, medicinal products and fuel*	
▪ Biomass fuel	▪ Ornamental resources
▪ Forage	▪ Timber and wood products
▪ Fresh water	▪ Mineral and petroleum products
▪ Genetic resources	
Regulating services *Benefits from ecosystems regulating ecological processes, such as the mitigation of flood and storm damage, and the purification of air and water*	
▪ Biological and natural pest control	▪ Ecosystem stability and resilience
▪ Biotic pollination	▪ Maintenance of soil health
▪ Carbon sequestration	▪ Nitrogen fixation
▪ Habitat provision	▪ Resistance to invasion by pests
▪ Provision of shade and shelter	▪ Protection from ultraviolet light
▪ Surface water eco-regulation	
Cultural services *Intangible benefits obtained from ecosystems, such as a sense of place, knowledge and religious fulfilment*	
▪ Aesthetic values	▪ Cultural heritage conservation
▪ Cultural identity and diversity	▪ Educational values
▪ Inspiration	▪ Knowledge systems (traditional and formal)
▪ Land value	▪ Natural heritage and biodiversity conservation
▪ Recreation and tourism	▪ Social relations
▪ Sense of place	
▪ Spiritual and religious values	

Ecosystem services	
Supporting services *Fundamental and overarching ecological processes underpinning all ecosystem functions, such as nutrient cycling*	
▪ Ecosystem dynamics and succession	▪ Carbon dioxide uptake
▪ Evolution	▪ Reproduction
▪ Maintenance of biodiversity	▪ Soil formation
▪ Nutrient cycling	▪ Water cycling
▪ Production of atmospheric oxygen	

The following sub-sections provide further information about several key values supported by the State Conservation Areas.

4.4.1 Refugia and connectivity

As shown in **Figure 4,** the NSW Brigalow and Nandewar bioregions have been extensively cleared for agricultural development. The State Conservation Areas, along with other Conservation Community Area zones and reserves, contain the most extensive area of native vegetation in the area west of the Great Dividing Range.

The State Conservation Areas are likely to provide important refugia for native fauna and flora, and are likely to act as nodes allowing organisms to move through native vegetation across the landscape. **Figure 5** identifies areas where connecting vegetation would provide the highest benefit to terrestrial biodiversity.

Nodes and connecting vegetation are important as they:

- **facilitate ecological processes and ecosystem services**, such as the flow of energy, nutrients and biota
- **contain a diverse range of vegetation communities and habitats,** to sustain viable populations of a wide variety of animal and plant species, including many that are threatened or declining within NSW and Australia
- **help species move through the landscape**, including dispersing individuals and nomadic and migratory species (further aided when vegetation corridors exist on private land)
- **enhance the capacity of ecosystems and systems to respond to significant biophysical change**, for example, allowing species and populations to alter their geographical range in response to projected changes in climate or recolonise areas they were previously lost from (Bennett, 2003b).

Species, especially large and specialised mammals and birds, tend to be lost from small and isolated patches of native vegetation (Ford et al., 2009; MacHunter et al., 2006). In contrast, populations remained in remnants that were well-connected to other vegetation.

Forests in the Pilliga and Goonoo State Conservation Areas are likely to be large enough to support viable populations of most animal species, provided that their habitat is available and maintained. However, other State Conservation Areas in the Brigalow and Nandewar region are much smaller and isolated, and as a result could lose species over time.

The loss of species in more isolated patches can be mitigated by protecting and enhancing existing habitat corridors, such as those in travelling stock routes, and by planting new corridors in appropriate locations (Freudenberger & Brooker, 2004). **Figure 5** shows suggested priority areas for connecting vegetation corridors on private land between State Conservation Areas and other Conservation Community Area zones and reserves. Over time, Local Land Services should lead strategic planning that identifies and invests in vegetation corridors in collaboration with local landholders in the region.

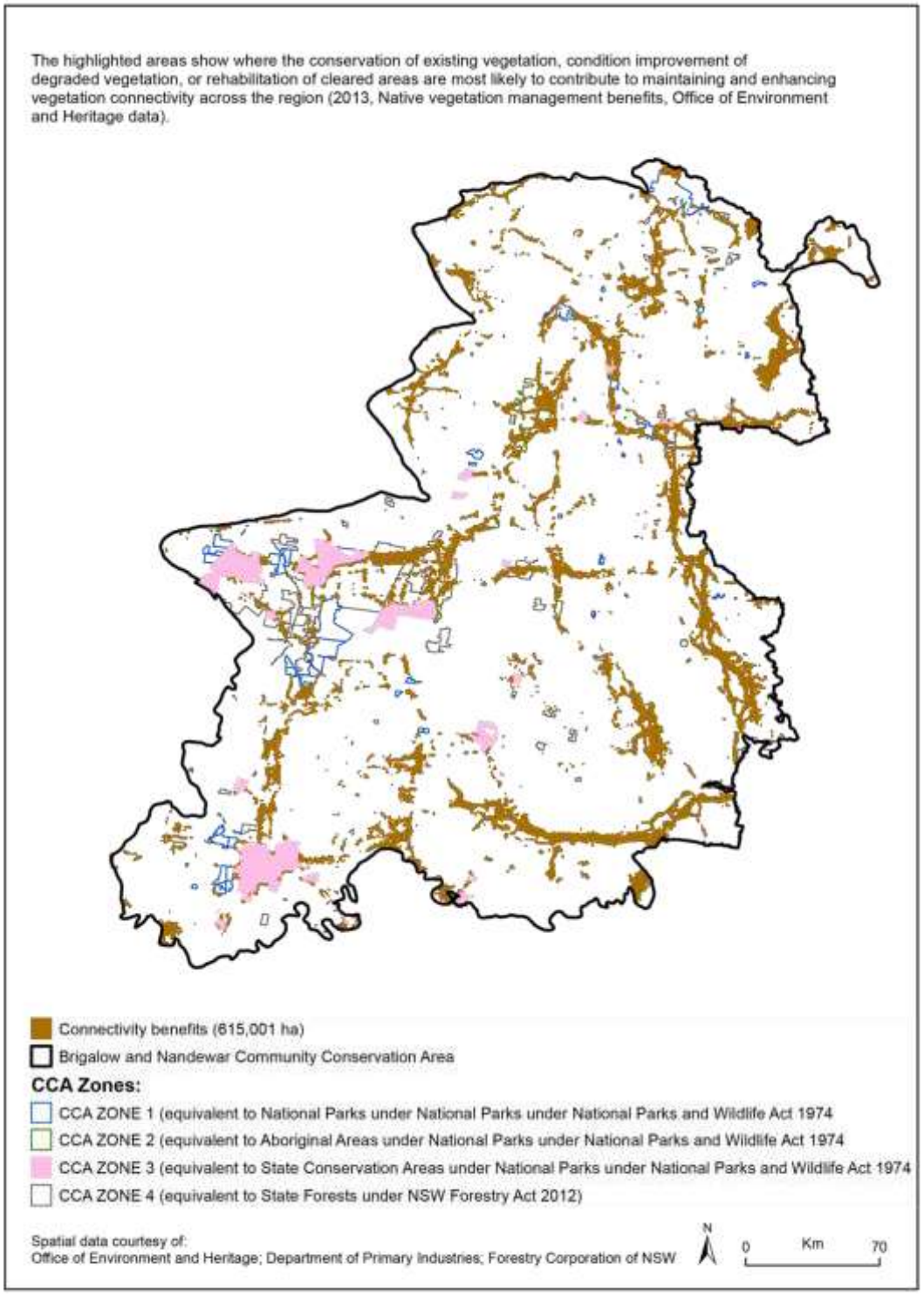

Figure 5: Indicative priority areas for achieving connectivity benefits in the Brigalow and Nandewar State Conservation Areas (after Drielsma et al., 2012)

4.4.2 Diverse flora and fauna

The Brigalow and Nandewar bioregions have a diverse assemblage of fauna and flora as they are located where the moist temperate (Bassian), moist tropical (Torresian) and inland (Eyrean) sub-regions meet and overlap (Andren, 2004; Date et al., 2002). Many stakeholder submissions received as part of this review acknowledged the diverse ecological characteristics, landscapes and vegetation communities within the State Conservation Areas.

Flora

A wide variety of vegetation types and plant species have been recorded in State Conservation Areas (see **Table 4** for examples). Typical canopy species include eucalypts[5], bloodwood[6], cypress[7] and bulloak[8] (Hunter, 2008a, 2008b, 2010, 2008c; Lindsay, 1967).

Table 4: Number of plant taxa, families and genera recorded in four State Conservation Areas

State Conservation Area	Number of vascular plant species[9]	Number of families	Number of genera
Biddon[(a)]	241	61	150
Bobbiwaa[(b)]	235	63	160
Pilliga and Pilliga West[(c)]	530	89	271
Trinkey[(d)]	358	124	217

References: (a) Hunter 2008a; (b) Hunter 2008b; (c) Hunter 2010; (d) Hunter 2008c.

The NRC analysed existing plant species composition data from field sampling of multiple white cypress pine forest stands in State Conservation Areas[10] to explore patterns of plant species composition within and between State Conservation Areas.

The NRC found that:

- plant biodiversity was high with 654 plant species recorded in samples across eight State Conservation Areas[11]; an average of 28.5 species per 20 x 20 metre plot (**Table 5**)
- plant species composition varied both within and between State Conservation Areas — on average each sample added 1.4 species to the observed species pool
- each State Conservation Area contributed to overall biodiversity adding 15 (2.3 percent of observed total) to 96 (14.7 percent) species to the observed species pool (Table 6).

5 For example, narrow-leaved ironbark (*Eucalyptus crebra*), Pilliga grey box (*Eucalyptus pilligaensis*), broad-leaved ironbark (*Eucalyptus fibrosa*), dirty gum (*Eucalyptus chloroclada*), yellow box (*Eucalyptus melliodora*), white box (*Eucalyptus albens*), grey box (*Eucalyptus microcarpa*), red gum (*Eucalyptus camaldulensis*) and silverleaf ironbark (*Eucalyptus melanophloia*).

6 For example, red bloodwood (*Corymbia gummifera*) and brown bloodwood (*Corymbia trachyphloia*).

7 White cypress pine (*Callitris glaucophylla*) and black cypress pine (*Callitris endlicheri*).

8 Bulloak (*Allocasuarina leuhmannii*), also commonly referred to as 'buloke', 'bull oak' or 'bull-oak'.

9 Vascular plants are land plants with lignified conducting tissues, such as ferns, conifers and flowering plants.

10 Surveys conducted in Biddon, Bobbiwaa, Killarney, Pilliga, Pilliga East, Pilliga West and Trinkey State Conservation Areas – see for example (Hunter, 2008a)

11 Published surveys suggest that typically pine and conifer forests have a plant diversity of around 25 species per standardised 0.04 hectare plot with a range of 6 – 48 species (see **Table A15.2**, **Attachment 15**). This puts several of the State Conservation Areas at the high end of this range.

- most species were infrequent in samples with over half the species recorded in fewer than 3 samples, and with few species common across all areas.

Attachment 15 provides more detail and results of this analysis.

Table 5: Plant biodiversity within State Conservation Areas

State Conservation Area	Number of plots sampled	Plant species richness [total species observed]	Number of species recorded in <5% of plots (% of total)	Likely total species richness[12]	Average number of plant species per plot
Biddon	23	213	90 (42%)	314	28
Bobbiwaa	21	182	71 (39%)	250	27
Pilliga West	8	131	-	175	32
Killarney	19	133	60 (45%)	233	25
Pilliga East	26	218	92 (42%)	321	28
Pilliga	77	391	261 (67%)	571	28
Trinkey	35	277	146 (53%)	390	32
Total	209	654	532 (79%)	-	-

Table 6: Contribution of each State Conservation Area to observed regional plant species pool

State Conservation Area	Number of plots sampled	Plant species richness (total species observed)	Number of species recorded only in the State Conservation Area	State Conservation Area contribution to observed plant species richness
Bidden	23	213	30	4.6%
Bobbiwaa	21	182	26	4.0%
Pilliga West	8	131	21	3.2%
Killarney	19	133	15	2.3%
Pilliga East	26	218	33	5.0%
Pilliga	77	391	96	14.7%
Trinkey	35	277	42	6.4%
Total	209	654	263	40.2%

12 Using Chao2 statistical method.

The NRC estimates there are around 90 vegetation communities (NSW Vegetation Classification and Assessment) associated with State Conservation Areas (see **Attachment 10** for full list) (Hunter, 2008a, 2008b, 2010, 2008c; Lindsay, 1967). Some typical vegetation communities recorded in State Conservation Areas include:

- narrow-leaved ironbark – white cypress pine
- green mallee – white cypress pine
- pilliga grey box – white box – myall
- white cypress pine – bulloak – white box
- bulloak – white cypress pine – narrow-leaved ironbark
- broombrush – granite heath
- dirty gum – white cypress pine.

Studies across part of the Pilliga identified nine major distinct floristic groups, of which grassy-box and white cypress pine woodlands, box-herb and riparian angophora red gum vegetation groups had the highest species richness of plants and birds (Binns & Beckers, 2001). Similar results have been found in State Conservation Areas (Hunter, 2008a). The studies also indicated white cypress pine was the most frequently recorded tree species (Binns & Beckers, 2001).

Fauna

Historically, 62 mammal species, 295 bird species, 112 reptile species and 25 frog species have been recorded in the region (Date et al., 2000). Around 15 of the historically recorded species are extinct, such as the bridled nailtail wallaby (*Onychogalea fraenata*) and black-throated finch (*Poephila cincta*) (Date et al., 2000). In addition, up to 28 orders of invertebrates have been recorded in the Pilliga State Forest (Dangerfield & Pik, 2001).

Many native species are most abundant in the Brigalow and Nandewar region, including two reptile and seven mammal species that are found only in this area (Date et al., 2000).

Other species, such as malleefowl (*Lepoia ocellata*), occur at the edge of their range in the region (Australian Government Department of the Environment, 2013c). For example, the Goonoo State Conservation Area is well known for its large population of glossy black cockatoos (*Calyptorhynchus lathami*), which are found at the western edge of their range (NSW Office of Environment and Heritage, 2014c).

The Pilliga forests are recognised for their significant contribution to koala (*Phascolarctos cinereus*) conservation in NSW; these forests have an estimated population of around 15,000 koalas (Kavanagh & Barrott, 2001). Although koalas rely on eucalypts for food resources, they use larger white cypress pine trees for daytime shelter (Kavanagh et al., 2007).

White cypress pine forests support fauna in the Brigalow and Nandewar State Conservation Areas by providing the following habitat resources:

- large, hollow-bearing eucalypts (important for species such as barking owls (*Ninox connivens*) and their associated prey) (Department of Primary Industries, 2009)
- larger trees of all species for shelter (for a range of birds, arboreal mammals and reptiles) (Paull & Date, 1999)

- heterogeneous stand structure with a mix of open and thick stands (for a range of avian species and bats) (Shelly, 2013)
- coarse woody debris (for birds, reptiles and mammals) (Bustard, 1968)
- loose hanging bark, including on stumps (for invertebrates) (Shelly, 2013)
- food resources such as bulloak (for example, for glossy black cockatoos) and white cypress pine seeds (Lacey, 1972)
- young healthy eucalypt regeneration (for koalas) (Kavanagh & Barrott, 2001).

4.4.3 Threatened habitats and species

There are 15 vegetation communities that are likely to be found in the State Conservation Areas listed as endangered ecological communities under the *Threatened Species Conservation Act 1995* (NSW), including 12 that are also listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (see **Attachment 10** for details).

Indicative distribution maps suggest there are 61 matters of national environmental significance across the broader Nandewar Community Conservation Area including:

- eight listed threatened ecological communities, for example the grey box (*Eucalyptus macrocarpa*) grassy woodlands and derived native grasslands of south-eastern Australia
- 62 listed threatened species, for example the square-tailed kite (*Lophoictinia isura*) and superb parrot (*Polytelis swainsonii*)
- 13 listed migratory species, for example the pied honeyeater (*Certhionyx variegatus*) (Australian Government Department of the Environment, 2013b).

According to the NSW Office of Environment and Heritage's BioNet Atlas of NSW Wildlife, 42 threatened native fauna species and 18 threatened native flora species have been recorded in the State Conservation Areas in the assessment area (see **Attachment 11** for full list of threatened species) (NSW Office of Environment and Heritage, 2013b).

Of these species:

- 13 are listed as endangered species and 44 are listed as vulnerable species under the *Threatened Species Conservation Act 1995* (NSW)
- 18 flora and fauna species are also listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), including six endangered species and 12 vulnerable species.

A further two fauna species are listed as being presumed extinct under both the NSW and Australian Government threatened species listings.

Most of the threatened fauna depend on, or are most abundant in, eucalypt woodlands with mature hollow-bearing and fallen logs and vegetation types such as grassy woodlands, grasslands or semi-arid shrublands (Date et al., 2000).

4.4.4 Recreation values

Some State Conservation Areas in the Brigalow and Nandewar region are used for recreational purposes, particularly the Pilliga and Goonoo, with visitation rates often depending on accessibility to the conservation area itself or proximity to towns (Curby & Humphries, 2002).

Current plans of management allow State Conservation Areas to be used for bushwalking, bird watching, four-wheel vehicle driving, cycling, mountain biking, horse riding and archery, while unauthorised recreational activities that may also be occurring include trail biking and pig hunting (NSW Office of Environment and Heritage, 2013e). A permit is held in Killarney State Conservation Area to provide a safety zone for a rifle range on adjacent Crown land (Office of Environment and Heritage, pers. comm., 14 May, 2014). Stakeholder submissions also referred to the use of the State Conservation Areas for recreational purposes, for example wildflower tours, bird watching tours and bike tours.

However, overall visitor and commercial tourism levels in the region are low, with less than 4 percent of day visitors visiting with the purpose of going to a national or state park (NSW National Parks and Wildlife Service, pers. comm., 1 November, 2013). Tourist visits in the region tend to concentrate in specific National Parks that are in close proximity to caves or cultural sites. For instance, in 2011 and 2012 more than 8,000 people visited Pilliga National Park (NSW National Parks and Wildlife Service, pers. comm., 1 November 2013), which features sandstone caves that are an important Aboriginal site for the Gamilaraay people (NSW National Parks and Wildlife Service, 2014). In 2012-2013 four tourist operators had commercial licences to enter the State Conservation Areas, but were not reported to have taken any clients into these areas (ibid.).

4.4.5 Research values

Some State Conservation Areas are used for research purposes; for instance, fauna, flora and cultural surveys have been carried out in the Trinkey and Wondoba State Conservation Areas (NSW National Parks and Wildlife Service, 2012a, 2012b).

4.4.6 Aboriginal cultural values

The State Conservation Areas lie within the traditional country of Aboriginal people, and forests within the region have traditional, historic and continuing cultural uses and meanings. At the time of European settlement the Gamilaraay and Weilwan groups lived in the region. Today, the region is still home to these groups and multiple Local Aboriginal Land Councils. State Conservation Areas are located in 15 Local Aboriginal Land Council regions (see **Figure 6**).[13]

Plants have historic and contemporary uses as food and medicine, and Aboriginal people continue to carry out social and spiritual activities in the region's forests (NSW National Parks and Wildlife Service, 2002a). Historically, the Pilliga and Goonoo State Forests were also important to Aboriginal people because of timber industry employment (NSW National Parks and Wildlife Service, 2002a).

There are currently 276 Aboriginal sites registered in the State Conservation Areas (see **Attachment 12)** (NSW Office of Environment and Heritage, 2013a). The highest number of sites

[13] Anaiwan, Baradine, Coonamble, Coonabarabran, Dubbo, Gilgandra, Moree, Mudgee, Narrabri, Pilliga, Red Chief, Tamworth, Walgett, Walhallow and Wee Waa.

are located in Goonoo State Conservation Area (97), followed by Biddon State Conservation Area (42). There are two registered native title claimants in the Brigalow and Nandewar region: the Gomeroi people and the Tubba-Gah people. The NSW Government is in negotiations with the Tubba-Gah people regarding management of the Goonoo State Conservation Area.

During NRC consultation with local Aboriginal stakeholders and through stakeholder submissions, the State Conservation Areas were identified as having ongoing value as:

- places of high cultural and spiritual significance where women's business and men's business continue to be practised
- places where burials are found
- areas where native fauna live.

They are also places in which skills, knowledge and traditions can be handed down, and where cultural education and training can occur, including cultural survey training for people in the Aboriginal community. For example:

- Biddon State Conservation Area has been used as a training area for Gilgandra TAFE students studying Indigenous Land Management, as part of a cultural site survey conducted in 2008 (NSW National Parks and Wildlife Service, 2012c)
- Trinkey State Conservation Area has been used for training the local Aboriginal community in undertaking cultural surveys (NSW National Parks and Wildlife Service, 2009)
- Wondoba State Conservation Area has been used for training the local Aboriginal community in undertaking cultural surveys (NSW National Parks and Wildlife Service, 2012b).

In oral history interviews, Aboriginal people have expressed concerns about the decline of waterways and native vegetation, and an associated decline in animal and plant bush foods (NSW National Parks and Wildlife Service, 2002a).

4.4.7 Non-Aboriginal cultural values

The State Conservation Areas have supported many different industries in the past. As a result almost all forests in the Brigalow and Nandewar region contain evidence of former pastoral, apiary and timber industry activities, including the white cypress pine timber industry and ironbark sleeper cutting industry (Curby & Humphries, 2002).

Forty-two heritage items or places of historic heritage have been recorded in the State Conservation Areas (Curby & Humphries, 2002). The highest number of these items or places is in Goonoo State Conservation Area (10), followed by Pilliga West State Conservation Area (nine). There are no State Heritage items or places in the State Conservation Areas; that is, no places identified as being important for the whole of NSW, and therefore 'state significant'. Registered historic heritage sites are listed in **Attachment 12**.

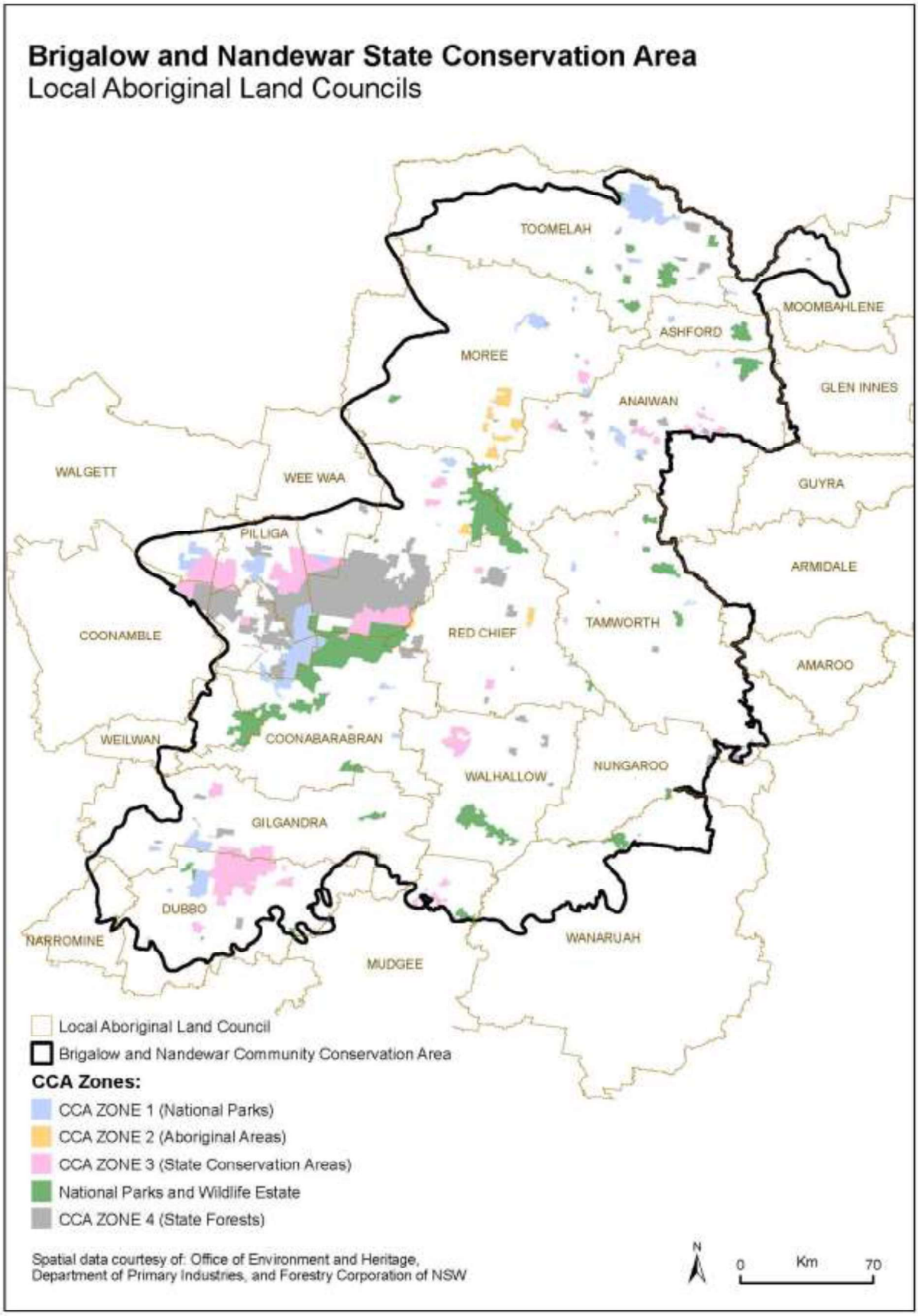

Figure 6: Map of Local Aboriginal Land Councils in the Brigalow and Nandewar region

4.4.8 Current economic values

Mineral and petroleum exploration and extraction

There is currently one active coal mine in the State Conservation Areas (Durridgere State Conservation Area) (NSW Department of Trade and Investment, 2013). In addition, there are currently 15 coal, 24 petroleum and 18 mineral licences held, as well as seven licence applications, in the State Conservation Areas (ibid.) (**Attachment 13**).

Across the Brigalow and Nandewar region, assessments have identified a wide range of potential mineral and petroleum resources (NSW Department of Mineral Resources, 2000, 2002) concluding that "for both coal seam methane and conventional hydrocarbon potential, the Pilliga region represents the most prospective portion of the State yet identified" (NSW Department of Mineral Resources 2000, pg. 5).

As a result of these potential resources, the mining and petroleum sector in the Brigalow and Nandewar region is growing. For instance, Santos currently holds a production lease for one coal seam gas well and a number of conventional gas wells in the Brigalow and Nandewar region, with a current proposal for an estimated $2 billion coal seam gas project, including a Regional Community Benefit Fund that could provide $160 million for regional programs and infrastructure (GHD, 2014; NSW Chief Scientist & Engineer, 2013). Along with previous project owner Eastern Star Gas, Santos has conducted significant exploration in the Gunnedah Basin (NSW Chief Scientist & Engineer, 2013), but has indicated it is currently not pursuing exploration in State Conservation Areas (Santos, pers. comm., 16 April 2014).

Apiary

State Conservation Areas also help to support an apiary industry. There are currently 327 apiary licences held by 45 licence holders within the State Conservation Areas, with the majority of apiculture activity occurring in the Goonoo State Conservation Area, followed by Pilliga and Pilliga East State Conservation Areas (NSW Office of Environment and Heritage, pers. comm., November 2013).

The Brigalow and Nandewar apiary industry employs 49 people, representing a small share of regional employment but a significant share of employment in the NSW beekeeping sector (17 percent excluding Sydney) (Australian Bureau of Statistics, 2011b).

Healthy bee populations are required for both honey production and crop pollination (Rural Industries Research and Development Corporation, 2013). According to the NSW Apiarists' Association Inc. (2013), the apiary industry relies on native forests and woodlands on public lands for access to nectar from flowering eucalypt species for honey production. Public forests and woodlands also provide areas for breeding, and a refuge for bees when agricultural insecticides are being sprayed in the area (Somerville, 1997).

Bees are moved into the State Conservation Areas seasonally, depending on flowering times. The industry can access apiary sites within the State Conservation Areas that were established under previous State Forest tenures, although new apiary sites in reserve areas are not permitted (NSW National Parks and Wildlife Service, 2002b).

Seventy percent of NSW's honey production is derived from eucalypt species (NSW Apiarists' Association Inc., 2013). Hence, important trees for apiaries are ironbarks, boxes and gums (Somerville, 1997). Previous management plans for State Forests in the Dubbo area identified that "cypress pines in the area are not generally regarded as having high apiary values" and

that "cypress pine forests have very limited occurrence of recognised honey producing species" (ibid.).

Grazing and forestry

State Conservation Areas do not allow grazing and commercial timber harvesting (NSW Government, 2009). However, these practices have historically been carried out in many of these areas under previous State Forest tenures.

Grazing was prevalent across the Brigalow and Nandewar region from the time of early settlement in the 1830s, and almost all forests in the region contain some evidence of past pastoral practices (Curby & Humphries, 2002; Resource and Conservation Assessment Council, 2002). Grazing in these areas was previously permitted by an occupation permit. Grazing records from the Office of Environment and Heritage indicate that prior to the establishment of the Community Conservation Area only one grazing permit was allocated in what are now the State Conservation Areas, in Durridgeree State Conservation Area (NSW National Parks and Wildlife Service, pers. comm., 21 February 2014).

Similarly, prior to the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) coming into effect in 2005, white cypress pine mills within the Brigalow and Nandewar region sourced white cypress timber from areas that were once State Forests and are now State Conservation Areas (Resource and Conservation Assessment Council, 2002).

Following the establishment of the Brigalow and Nandewar Community Conservation Area in 2005, a reduction in State Forest area led to a decrease in the sustainable white cypress yield (Forests NSW, 2008). This prompted a NSW Government-funded restructure of the NSW white cypress pine industry (Natural Resources Commission, 2010b). In the Brigalow and Nandewar region, the industry associated with white cypress pine consolidated into three white cypress pine timber milling businesses (one of which has not received significant volumes of white cypress pine in 2012 and 2013), two integrated harvest and haulage operators and one processing business producing landscaping products. These businesses are located in Baradine and Gunnedah.

In 2006, the former Forests NSW entered into 20-year wood supply agreements with the major timber harvesting and milling companies in the region (Forests NSW, 2008). The agreements guarantee supply of a fixed white cypress pine wood volume until December 2025, sourced from State Forest tenure (ibid.).

The historical management of these forests is discussed in further detail in **Section 6.3** and **Attachment 14**.

Other

There are two permits for telecommunication facilities in the Pilliga East State Conservation Areas (Office of Environment and Heritage, pers. comm., 30 April 2014).

5 Active and adaptive management

Key points

KP 5.1 Traditional approaches to reserve management have not been able to deal with the complexity or uncertainties inherent in most natural systems. As a result, NSW is trialling a more active and adaptive approach to landscape management including ecological thinning and further grazing in some reserves.

KP 5.2 Although active and adaptive management is well suited to addressing the complexity and uncertainties involved in managing the State Conservation Areas, current plans of management do not take an adaptive approach.

KP 5.3 Taking an active and adaptive approach provides land managers with the necessary management flexibility, discretion and response to better understand and address existing and emerging landscape issues, and accelerate the rate of progress towards desired landscape outcomes.

KP 5.4 Active and adaptive management may prove to be a more cost effective investment than future attempts to restore a degraded landscape or protect a threatened species from further population decline.

Draft recommendations

2(a) The NRC recommends that the NSW Government develop and implement an Adaptive Management Plan for the Brigalow and Nandewar State Conservation Areas, based on the adaptive management framework set out in **Table 7**.

5(a) The NRC recommends that the Adaptive Management Plan for the State Conservation Areas be a legislative requirement, to be completed by the Office of Environment and Heritage within a specified time and approved by the Minister for the Environment, and include specific, measurable and spatially explicit management targets.

3(a) The NRC recommends that consistent with the overarching Adaptive Management Plan, new or revised plans of management for State Conservation Areas should be developed. It is proposed that the 23 State Conservation Areas in the assessment region be consolidated into a smaller number of functional groups to streamline planning and administration processes. Any such groupings should be subject to consultation with relevant National Parks and Wildlife Regional Advisory Committees.

This chapter explains what is meant by the term 'active and adaptive management' in the context of the Terms of Reference, and provides some information about how active and adaptive management is being used in practice. It presents an overview of current management arrangements in the State Conservation Areas, and discusses why active and adaptive management is the best practice approach to managing dynamic ecological systems, such as those found within State Conservation Areas.

5.1 Understanding active and adaptive management

Traditional approaches to reserve management have not been able to address the complexity or uncertainties inherent in most natural systems. This is because conventional approaches assume that reserves are ecologically static and will retain a full range of values through time with minimal intervention (Spooner & Allcock, 2006; Stankey & Allen, 2009; Stankey et al., 2005; Westoby et al., 1989).

Active management can be defined as deliberate interventions in the landscape to meet a specified objective (Young et al., 2005). **Adaptive management** is a formal framework for inquiry that helps managers ensure that interventions are contributing to the stated management objectives, and learn about what interventions work best to improve their management strategies over time (Kingsford & Biggs, 2012; Williams, 2011).

Interventions are most effective when implemented as part of an adaptive management process (McLain & Lee, 1996; Williams, 2011). In this report **active and adaptive management** refers to the deliberate application of a range of management interventions within a formal framework for evaluation, learning and adaptation.

5.1.1 Active management

Active management refers to intentional human interventions in a landscape in order to achieve desired environmental, social, cultural or economic objectives or outcomes (after Young, Petersen & Clary 2005). Most conservation practitioners and researchers accept that direct human interventions may be necessary in some circumstances to achieve desired conservation goals and objectives (Hobbs et al., 2011; Franklin, 2003).

Active management can either maintain current states, or intentionally 'jolt' ecological systems into transition towards new desired states with the overall intent being to accelerate progress towards desired management goals and targets (Westoby et al., 1989). For example, degraded landscapes may not always naturally transition towards more desirable states, or may not do so within an acceptable timeframe. In these instances, intervention may be appropriate to improve landscape values.

The Office of Environment and Heritage's Corporate Plan has identified that it will "actively manage and protect valued ecosystems, landscapes and places, such as national parks and floodplain wetlands" to "ensure vibrant natural assets for the health and prosperity of NSW" (NSW Office of Environment and Heritage, 2013c). Currently, the active management interventions used within the Brigalow and Nandewar State Conservation Areas are prescribed fire and pest and weed control to protect and conserve natural and cultural values and human life and property (NSW National Parks and Wildlife Service, 2012c, 2013).

Internationally, the United States and Canada are increasingly applying active management within forest landscapes (Stephens, 2013). For example, the United States' Forest Service is applying interventions in their forest management to "increase the pace and scale of forest restoration" (United States Department of Agriculture 2012, page 3). Approximately 12.5 million acres of the United States' National Forest System has been identified as needing mechanical treatment to "address decades of fire suppression, insect mortality, invasive species, the effects of climate change and the associated build-up of hazardous fuels to restore more natural forest conditions" (United States Department of Agriculture 2012, page 4).

5.1.2 Adaptive management

Adaptive management is a formal framework for inquiry that, together with effective monitoring and evaluation, helps ensure interventions are contributing to stated management objectives, and also assists managers to learn about what interventions work best to improve their management strategy over time (Kingsford & Biggs, 2012; Williams, 2011). Put more simply, adaptive management can be described as 'learning by doing' (Duncan & Wintle, 2008).

The complexity of natural systems means there will always be some uncertainty remaining around what is causing a landscape issue, and how an ecosystem will respond to different interventions (Stankey et al., 2005). Despite, or because of, this inherent complexity and uncertainty, managers are often hesitant to intervene on the ground without complete or perfect knowledge about landscape function and how the landscape will respond to proposed actions (Craig & Ruhl, 2014).

In some cases, this inaction places ecosystems at risk of crossing a 'threshold of concern' (or tipping point), whereby the system shifts from areas of acceptable condition (within acceptable levels of natural variability) into an undesirable alternate state (see **Figure 7**). In some systems, it may be possible to describe a transitional state or phase where a system is starting to show some characteristics of an alternate state (Chapin III et al. 2009).

In many cases, the exact tipping point of a system may not be known. However, land managers can often tell when a landscape has shifted to an alternate state, as it may begin to behave or function differently compared to its behaviour or function within the area of acceptable condition (Central West Catchment Management Authority, 2011). Once a threshold of concern has been crossed, it may be difficult or sometimes impossible for the landscape to return to the previous state and support its previous values (Haines-Young et al., 2006).

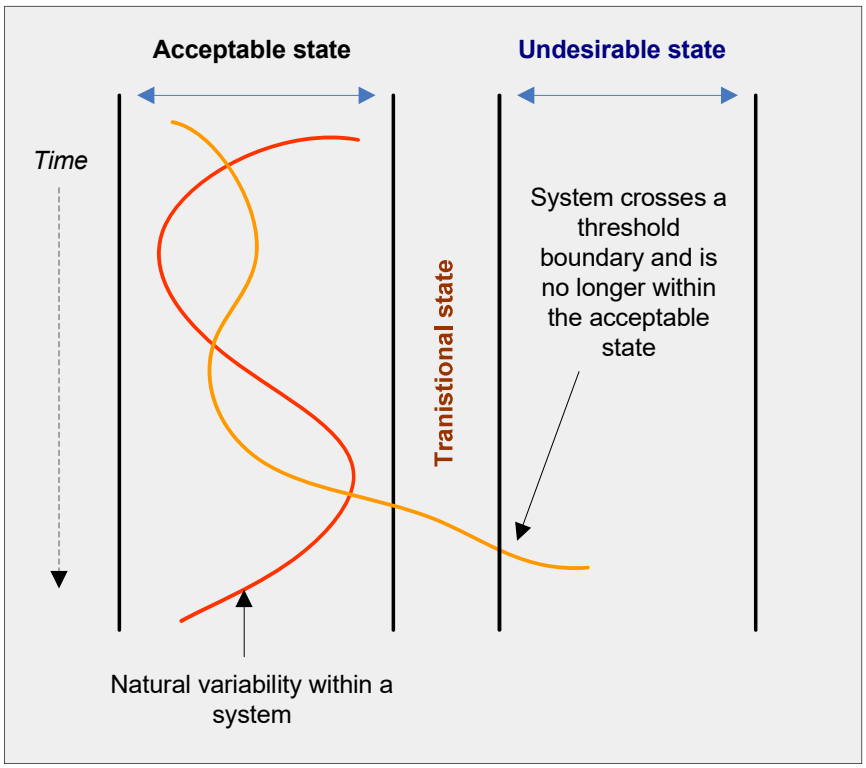

Figure 7: Conceptual model of systems dynamics containing key concepts such as acceptable and undesirable states and thresholds of concern (adapted from Central West Catchment Management Authority 2011)

Adaptive management is therefore about developing and implementing a 'plan for learning' (Parma et al., 1998). It is not about incremental improvement based on observations of 'business as usual' management, but about intervening purposefully in order to obtain new information and insights (Stankey et al., 2005). Once a potential landscape problem has been identified and management objectives defined, managers are encouraged to treat management actions as experiments, drawing on scientific methods to develop and test hypotheses about how different interventions will help achieve the stated objectives (Stankey et al., 2003).

The framework presented in **Table 7** shows the key elements of effective adaptive management. This framework draws on the National Parks and Wildlife Service's existing documents supporting an ecological thinning trial in the river red gum reserves (NSW Office of Environment and Heritage and Parks Victoria, 2012).

It is important to recognise that these steps are not necessarily linear, and working through this framework should be an iterative process. Adaptive management also works best as a collaborative process, in which key stakeholders are involved in the design of the adaptive management plan in order to build a shared understanding of key issues and facilitate change (Stankey et al., 2005; Williams, 2011).

Table 7: Example of an adaptive management framework (adapted from NSW Office of Environment and Heritage and Parks Victoria 2012)

Key elements of the adaptive management framework	
1. Identify areas for improvement	An unambiguous statement of the management problem or area for improvement that is to be addressed through adaptive management is required.
2. Specify management goals and objectives	Specify the goals and objectives for adaptive management. Ideally, objectives should include the degree of desired change, the expected time frame and a minimum level of certainty. The objective may be stated in terms of a desired state for the ecosystem.
3. Document a process model	A process model that documents knowledge and uncertainty about natural processes that underpin existing states of the system, and moderate the transition from a current to an alternative state. Models provide context for potential management interventions that may facilitate transition. They may highlight a lack of knowledge about a system, and may result in modification of objectives.
4. Select management options and implement	Multiple management options may be plausible, and selection criteria can be applied to select options that will be trialled. Ideally, selection criteria should spread the risks of management failure and improve system responses to management (Keith et al., 2011). The process model is used as the basis of specifying hypotheses that will be tested, in terms of expected changes in the variables characterising alternative states that will be brought about by the chosen management actions.

Key elements of the adaptive management framework	
5. Design and implement a monitoring, evaluation and reporting plan	Identify variables that have a known relationship with the subjects of the hypotheses, and design a monitoring plan that collects data with sufficient accuracy to address the hypotheses, and thereby evaluate the relative merits and limitations of alternative management strategies. It may be necessary to prioritise the monitoring variables (and hypotheses) to meet resource and budgetary constraints.
6. Iterative modification of the process model and management objectives	Information from the experimental trial may alter the underlying process model, and stimulate subsequent phases of adaptive management in which objectives are modified, the chosen management options are further explored, or a new set of management options is trialled.

5.2 Adaptive management in practice

Adaptive management is not new – it has been identified as a necessary component in a broad range of fields, from natural resource management to financial systems, drug and medical device warnings, and social welfare (Craig & Ruhl, 2014; Hollings, 1978). Internationally, South Africa is a leading proponent, with strategic adaptive management being successfully pioneered in Kruger National Park, and subsequently implemented across all South African National Parks (South African National Parks 2008).

However, examples within scientific literature indicate adaptive management has often been applied ineffectively or ambiguously (Allen & Gunderson, 2011; Rist et al., 2013; Susskind et al., 2012; Westgate et al., 2013). Proposed explanations for past implementation issues include:

- constraints brought about by the administrative procedures and laws of conventional regulatory approaches (Craig & Ruhl, 2014; Ruhl, 2005)
- stakeholder scepticism and concern that an adaptive management approach allows for too much discretion (Shultz & Nie, 2012).

Because of these issues, agencies have often taken a cautious approach and applied a watered-down version of adaptive management (Ruhl & Fischman, 2010). However in their recent review, Westgate, Likens & Lindenmayer (2013) identified a growing number of projects in which adaptive management is being successfully applied.

Importantly, land managers in NSW are increasingly applying learning-oriented active and adaptive management approaches, and there are many policy settings in place that support active and adaptive management in the State Conservation Areas.

In particular, within the Office of Environment and Heritage, the National Parks and Wildlife Service has commenced implementing trials within an adaptive management framework on its reserve system under a formal, state-wide Landforms and Rehabilitation Team (NSW Office of Environment and Heritage, 2014d). For example, National Parks and Wildlife Service land managers are implementing:

- an ecological thinning trial in river red gum reserves, in collaboration with Parks Victoria (NSW Office of Environment and Heritage, 2014b)

- a grazing trial across the south-western cypress and river red gum reserves (NSW Office of Environment and Heritage, 2013d).

The ecological thinning trial is designed to accelerate the rate of learning around thinning interventions by testing two different thinning treatments (heavy and moderate) against outcomes in control stands (NSW Office of Environment and Heritage, 2014b).

The Australian Government's *Strategy for the National Reserve System 2009-2030* also recognises that adaptive management and regular performance reviews are essential to achieving specified goals for future landscapes (Commonwealth of Australia, 2009).

5.3 Improving management in the State Conservation Areas

Plans of management guide management activities in State Conservation Areas. These plans are legal documents that explain how a reserve will be managed, and are required for all reserves under the *National Parks and Wildlife Act 1974* (NSW). To date, the Office of Environment and Heritage has completed final plans of management for three of the 23 State Conservation Areas (Biddon, Bullawa Creek and Leard), while a further two draft plans (Trinkey and Wondoba) have been released for public consultation.[14]

The current plans of management allow for active management through pest and weed control and bushfire management, but do not apply these interventions within an adaptive management framework. This means management assumptions are not being fully understood, documented and tested, and opportunities for learning and improvement of current management approaches are being missed.

If correctly applied, adaptive management is a useful framework for actively managing dynamic landscapes such as the State Conservation Areas. Taking an active and adaptive approach provides land managers with the necessary management flexibility, discretion and response to better understand and address existing and emerging landscape issues, and accelerate the rate of progress towards desired landscape outcomes. Active and adaptive management provides a way of managing risks associated with management interventions, as well as risks associated with undesirable future landscape trajectories.

While taking a proactive approach to landscape management requires an up-front investment of resources, it may also deliver long-term savings. Parts of the northern section of the Brigalow and Nandewar Community Conservation Area lie on the edge of one of Australia's 15 national biodiversity hotspots, where natural values have been identified as being at risk in the absence of active conservation management (Australian Government Department of the Environment, 2013a). The Australian Government propose that undertaking management actions now will be more cost-effective than trying to restore hotspots once they have degraded and plants and animals have become endangered (Australian Government Department of the Environment, 2007).

Table 8 describes the key policy conditions that suit adaptive management, and explains its particular relevance for the Brigalow and Nandewar State Conservation Areas.

14 See environment.nsw.gov.au/parkmanagement/ParkManagementPlans.htm (accessed 21 December 2013).

Table 8: Key policy conditions for the application of adaptive management and relevance to State Conservation Areas

Conditions for adaptive management (after Craig & Ruhl 2014)	Relevance to Brigalow and Nandewar State Conservation Areas
Dynamic management context where change occurs in response to environmental conditions as well as management interventions	✓ Like all reserves, the State Conservation Areas are found in landscapes that consist of complex interacting and interdependent physical, biological and social components which have been, and currently are, subject to a range of natural and human disturbances.
Policy makers and managers have incomplete knowledge of the management context and system dynamics (uncertainty is high) but can manipulate through interventions (controllability is high) without causing irreversible damage (risk is low)	✓ The full extent of environmental benefit from a range of proposed additional active management options in the State Conservation Areas is uncertain (see **Chapter 9**). While the physiological and ecosystem response of white cypress pine under forestry is relatively well known, optimal treatments and prescriptions for conservation outcomes need further investigation.
Policy makers and managers have clear management objectives and capacity to use experimentation and option testing	✓ Current legislation and relevant agreements provide sufficient direction and scope to experiment and test options. However, management objectives could be more strongly linked to conceptual models of system dynamics to help understand uncertainty, identify knowledge gaps, select the best management options and focus learning.
Policy makers and managers have the capacity to, monitor and evaluate and a strong culture to learn, reflect and adjust policy and management decisions in a timely manner	✓ The Office of Environment and Heritage has scientific and technical capacity and experience, including adaptive management experience within the National Parks and Wildlife Service Landforms and Rehabilitation Team. The region also has connections to universities and research institutions to support collaborative monitoring, evaluation, research and reporting processes.
Policy makers and managers have sufficient funding and resources and the political and stakeholder support needed to implement adaptive management	✓ Adaptive management has previously been funded and implemented in the river red gum forests (thinning trial) and south-western cypress forests (grazing trial). The state-wide National Parks and Wildlife Service Landforms and Rehabilitation Team includes adaptive management expertise. ? Likely stakeholder support will be evaluated after further consultation.

The NRC recommends that the NSW Government facilitate best-practice active and adaptive management for the Brigalow and Nandewar State Conservation Areas by adopting the adaptive management framework described in **Table 7**. This approach should continue to position the Office of Environment and Heritage's National Parks and Wildlife Service as a demonstrated leader in active and adaptive management.

However, the current regulatory approach to conservation management in NSW may constrain effective implementation of active and adaptive management; for example, where management and planning processes can be limited by overly prescriptive regulation (Craig & Ruhl, 2014).

5.4 An Adaptive Management Plan for State Conservation Areas

The NRC recommends that the Office of Environment and Heritage develop an Adaptive Management Plan that will apply across all State Conservation Areas in the Brigalow and Nandewar Community Conservation Area.

The NRC proposes that the Adaptive Management Plan be a legislative requirement, to be approved by the Minister for the Environment. The Office of Environment and Heritage should develop and implement the Adaptive Management Plan within a specified time period, and include specific, measurable and spatially explicit management targets.

Within the Office of Environment and Heritage, the National Parks and Wildlife Service has commenced implementing trials within an adaptive management framework on its reserve system within their Landforms and Rehabilitation Team. The National Parks and Wildlife Service's Landforms and Rehabilitation Team should be well-placed to lead the development and implementation of the Adaptive Management Plan in collaboration with staff from the relevant regional areas.

This plan should set out the principles and processes for adopting an active and adaptive management approach across the State Conservation Areas, drawing on the adaptive management framework provided in **Table 7**.

Further details around governance, accountability, legislative considerations, and monitoring and evaluation for the Adaptive Management Plan are provided in **Chapter 13**.

5.4.1 Developing active and adaptive plans of management

Under the Adaptive Management Plan, the development of new or revised plans of management for each State Conservation Area based on an active and adaptive management approach should be a priority. In particular, plans of management for State Conservation Areas identified as having significant potential areas of management concern should be prioritised (refer to **Section 9.3** and for analysis of potential areas of management concern and management priority in State Conservation Areas).

Plans of management for State Conservation Areas (where they exist) manage an entire State Conservation Area as one management unit for many conservation issues. The NRC considers this scale too coarse to adequately address on-ground diversity, especially for large State Conservation Areas such as Goonoo and Pilliga West. Recently, the National Parks and Wildlife Service has moved towards finer-scale spatial fire management units based largely around ecological thresholds.

The NRC recommends that new and revised plans of management for State Conservation Areas should also contain discrete, finer scale spatial management units nested within the boundaries of the State Conservation Areas. This would provide land managers with greater ability to tailor and target management objectives and actions in individual areas. This approach can also provide a stronger accountability framework to track progress towards objectives and return on investment.

The remaining chapters in this report provide more detail around how interventions within an adaptive management framework could be used to address a specific landscape issue – in this case, large stands of dense white cypress pine – and improve ecological outcomes in the white cypress pine forests in the Brigalow and Nandewar State Conservation Areas.

5.4.2 Consolidating State Conservation Areas

Many of the 23 State Conservation Areas in the assessment area are relatively small in size and isolated across the landscape, including the Adelyne, Bullawa Creek and Woodsreef State Conservation Areas. Others are large, and form part of a larger functional group of contiguous reserves (and State Forests) such as Pilliga, Pilliga East and Pilliga West.

The NRC believes the 23 State Conservation Areas could be consolidated into a smaller number of functional groups to streamline the planning and administration process. This is already evident in some State Conservation Areas, for example Durridgere and Bingara State Conservation Area. This is also consistent with the approach taken in the conversion of former State Forests into south western cypress and river red gum reserves.

Any such consolidation of State Conservation Areas should be subject to consultation with relevant National Parks and Wildlife Regional Advisory Committees. **Table 9** provides an example of an initial proposal for the consolidation of State Conservation Areas. This proposal suggests reducing the current number of State Conservation Areas from 23 to eight, however, issues such as Native Title claims, National Parks and Wildlife Service's administration boundaries, other reserves and sub-IBRA (Interim Biogeographic Regionalisation for Australia) regions should be considered in any consolidation.

Table 9: Proposed consolidated State Conservation Areas

Consolidated State Conservation Area	Current State Conservation Area		NPWS region
Pilliga	1	Merriwindi	Northern Plains
	2	Pilliga	
	3	Pilliga East	
	4	Pilliga West	
Bobbiwaa	5	Bobbiwaa	Northern Plains
	6	Killarney	
	7	Bullawa Creek	
	8	Leard	
Trinkey	9	Trinkey	Northern Plains
	10	Wondoba	
Goonoo	11	Goonoo	Northern Plains
Cobbora	12	Adelyne	Northern Plains
	13	Cobbora	
Biddon	14	Biddon	Northern Plains
	15	Beni	
Durridgere	16	Durridgere	Blue Mountains
	17	Goodiman	
Northern Tablelands	18	Bingara	Northern Tablelands
	19	Goonoowigal	
	20	Gwydir River	
	21	Tingha Plateau	
	22	Warialda	
	23	Woodsreef	

6 Overview of white cypress pine ecology and potential impacts

Key points

KP 6.1 Previous studies suggest the State Conservation Areas are modified landscapes where historical disturbances – such as previous forestry management practices, fire suppression and fluctuations in pest populations such as rabbits – have changed the forest structure and composition when compared with the pre-European landscape.

KP 6.2 The scientific literature indicates that white cypress pine populations have increased relative to eucalyptus species in State Conservation Areas. Information provided by stakeholders also supports an increase in white cypress pine density, including discrete areas with large stands of dense white cypress pine. These vegetation changes are likely to have negative impacts on the ecological values of these areas.

KP 6.3 The NRC has concluded that small patches of dense white cypress pine regeneration within the State Conservation Areas provide important habitat within a landscape mosaic. However, large areas of dense, structurally homogenous white cypress pine are less likely to support ecological values compared with a landscape mosaic of different vegetation types and structures.

KP 6.4 The NRC supports the general hypothesis that actively managing large stands of dense white cypress pine should provide a more structurally and floristically diverse habitat mosaic within the State Conservation Areas. This hypothesis should be tested within an adaptive management framework.

This chapter explores the context and scientific literature in relation to potential management issues around dense white cypress pine within the Brigalow and Nandewar State Conservation Areas. It represents the first step of 'problem formulation' within the adaptive management framework described in **Table 7**.

6.1 Identifying current management issues

In the State Conservation Areas, the National Parks and Wildlife Service has inherited a modified landscape. At a landscape level, a combination of natural disturbances and climatic and biophysical factors has ensured that the State Conservation Areas are reasonably heterogeneous, with a mix of diverse plant communities (**Section 4.4.2** provides more detail on the diverse flora within these areas). At a finer scale, the structure, composition and values of white cypress pine forests within the State Conservation Areas are likely to be a legacy of past disturbances given the history of fire and drought, combined with varied management practices over time.

Stakeholders within the Brigalow and Nandewar region – through submissions to this review and also through the inquiry into the management of public land in New South Wales – have indicated that they believe current management within the State Conservation Areas may not be delivering optimal ecological outcomes (NSW Government, 2013). In particular, stakeholders indicated that a lack of white cypress pine thinning may be impacting on biodiversity and increasing the risk of areas with 'uninhabitable monocultures' (NSW Government, 2013, pg. 130).

To better understand this and other potential management issues, the NRC:

- reviewed the likely pre-European landscape and management, as well as the management history and changes within the landscape since European settlement
- developed system models to investigate how the white cypress pine forests and woodlands may function under different management regimes
- used best available evidence to describe how past management has impacted the current ecological values in these areas
- assessed what the current management regime may mean for future forest values in affected areas.

6.2 The pre-European landscape

There is ongoing debate around the structure and composition of Australian temperate woodlands in the Brigalow and Nandewar region prior to European settlement. Some argue that temperate woodlands had reasonably high tree densities dominated by eucalypts, while others suggest that these areas had reasonably low tree densities and more areas of open forest and tussock grassland (see **Figure 8** for an example of the latter) (Jurskis, 2009; Lunt et al., 2006; Noble, 1993; Norris et al., 1991; Rolls, 1981; Wyatt, 1989).

Figure 8: Example of an open forest and tussock grassland in Beni State Conservation Area

The NRC has developed a generalised model of the likely structure and composition of Australian temperate woodlands with white cypress pine in the Brigalow and Nandewar region prior to European settlement based on previous research (**Figure 9**). This model illustrates widespread, commonly encountered changes, and is not intended to apply to any specific State

Conservation Areas. Individual reserves have experienced variations in disturbances and consequent changes.

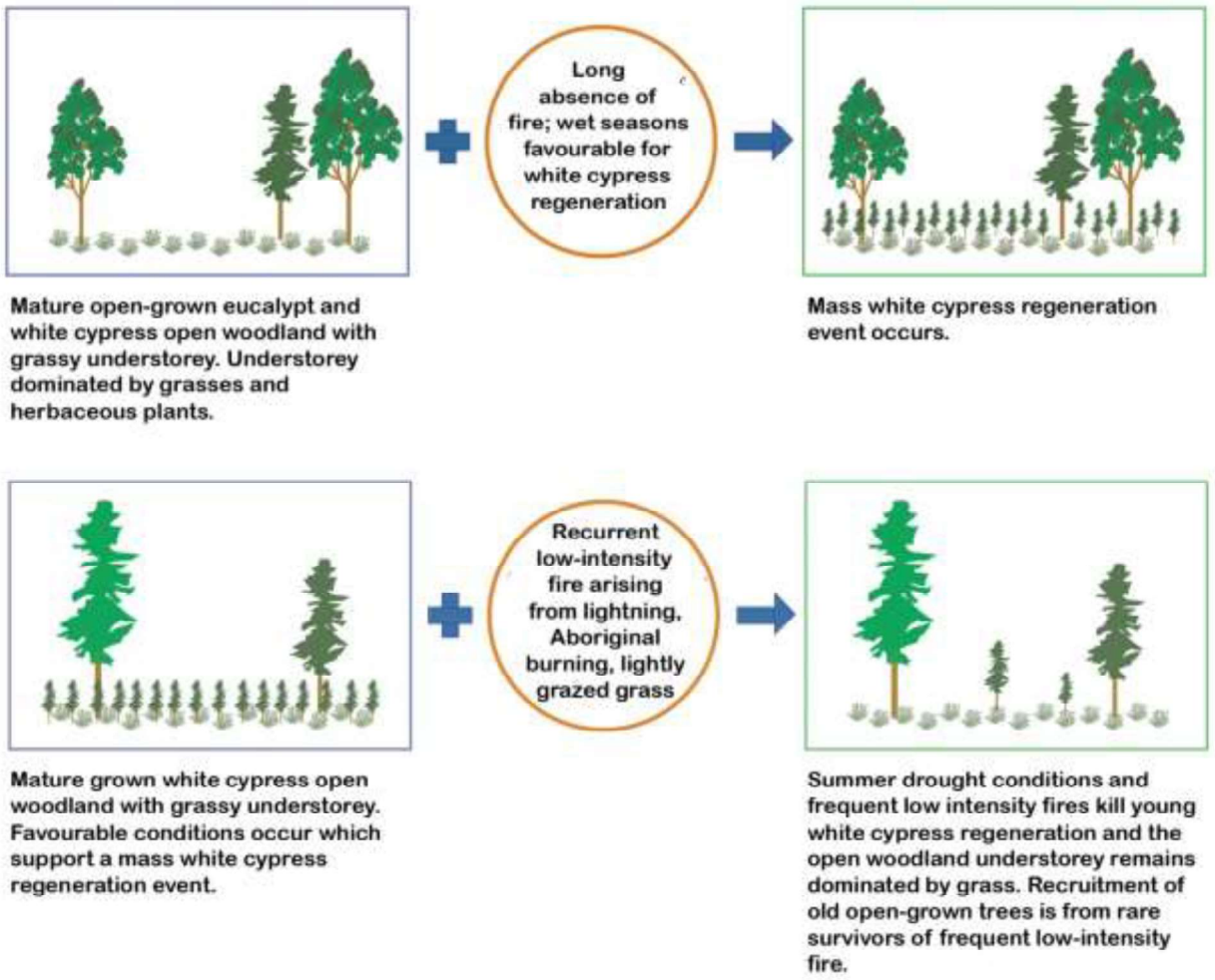

Figure 9: Generalised model of the structure and composition of Australian temperate woodland types with white cypress pine prior to European settlement

Key drivers in this system would have included fire, light grazing by native animals and climatic influences such as droughts and seasonal rains. The presence or absence of these factors would have influenced whether cypress or eucalypt species were dominant in a given area (Horne, 1990).

Fire would have limited the extent and distribution of fire-sensitive species, such as white cypress pine, within grassy landscape areas, particularly in comparison with more fire-tolerant eucalypt species (Jurskis, 2011). Prior to European settlement, it is thought that fires in the grasslands and grassy woodlands of western NSW were more frequent, due to a combination of higher levels of native grass cover, unrestricted spread of lightning fires and the likely use of fire in the landscape by Aboriginal people for ease of hunting (Flannery, 1994; Gammage, 2011; Jurskis, 2011; Pyne, 1992; Ryan et al., 1995).

6.3 Changes in the landscape following European settlement

Since European settlement in the 1800s, the Brigalow and Nandewar region has been intensively developed for agriculture (Benson, 1999; Curby & Humphries, 2002). State Conservation Areas are found within a landscape in which approximately 60 to 70 percent of the original vegetation has now been cleared (Benson, 1999; Resource and Conservation Assessment Council, 2002; Wells et al., 1984). The current distribution of white cypress pine and the vegetation communities is more fragmented than it was during pre-European distribution (**Figure 4**), where it formed part of a more extensive forest and woodland mosaic across the landscape (Forestry Corporation of NSW, 1989; Lacey, 1973).

In an effort to preserve timber values in an increasingly cleared agricultural landscape, forestry reserves (many of which are now State Conservation Areas) were declared in the Brigalow and Nandewar region as early as the 1870s, and were converted to State Forests in the 1910s (Curby & Humphries, 2002). These forestry reserve areas were actively managed primarily for white cypress pine and ironbark timber values. For instance, white cypress pine stands were being thinned under Improvement Leases prior to 1914 (Lindsay, 1967).

Although there is some debate about the exact structure and composition of the pre-European landscape, there is a general consensus on the timeline of important events since European settlement (**Figure 10**) and that the following broad changes have occurred in the landscape:

- open grassy white cypress pine woodlands with large over-mature trees are now rare
- many formerly open grassy white cypress pine woodlands have transitioned to denser forest or scrub formations
- white cypress pine has become dominant in many formerly eucalypt-dominated mixed pine and hardwood woodlands (Date et al., 2002; Lunt et al., 2006, 2011; Thompson & Eldridge, 2005b).

For instance, there is evidence to suggest the ratio between mature eucalypts and white cypress pine has shifted in favour of cypress (Lindsay, 1967; Rolls, 1981; Thompson & Eldridge, 2005b). Silvicultural activities since the 1890s, such as ironbark sleeper cutting and the removal or ringbarking of eucalypts to reduce competition with white cypress pine are likely to have contributed to this shift (Rolls, 1981; Thompson & Eldridge, 2005b).

Fire frequency is also likely to have significantly decreased as traditional Aboriginal burning ceased, livestock grazing began, and rabbit plagues affected fuel loads and regeneration (Keith, 2004; Rolls, 1981). This favours white cypress pine regeneration over eucalypt regeneration, as frequent fire promotes eucalypt-dominated vegetation communities (Gill, 1981).

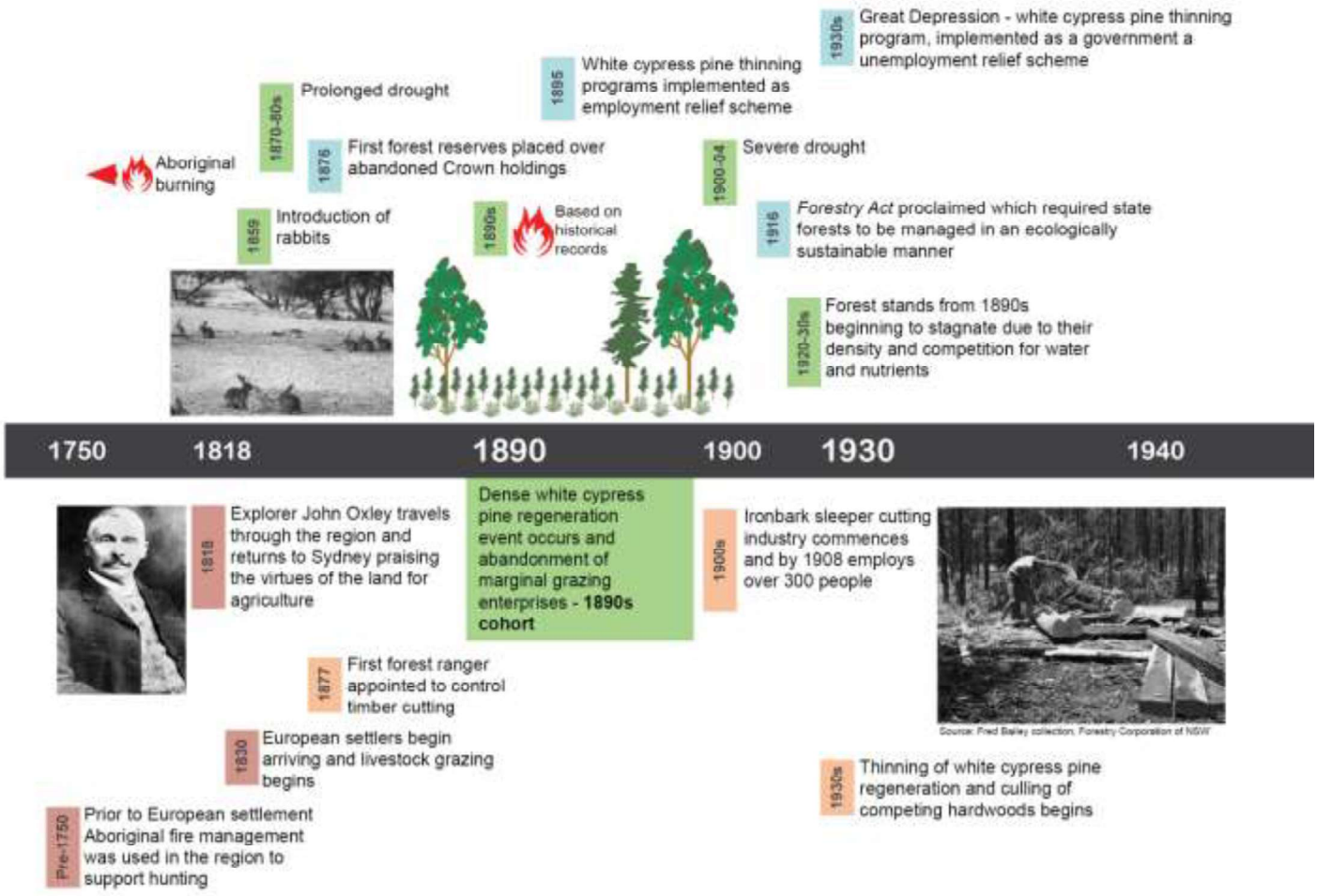

Figure 10: Landscape history overview for the Brigalow and Nandewar State Conservation Areas[15]

15 For more information on landscape history in the Brigalow and Nandewar State Conservation Areas see **Attachment 14**.

1950s Myxomatosis, a viral disease, was introduced to control the rabbit plague

1951

1957

1958

1966

1968 The Pilliga Nature reserve is established

1974

1982

1997 140,000 hectares

2003 White cypress pine can either be cleared, or thinned on private property with approval under the *Native Vegetation Act 2003* and associated regulations

2006 Winter and spring are the driest on record, lightning ignites several fires. A series of wildfires burn over 300,000 hectares of forest.

2007-08

2013 White cypress pine can be cleared or thinned without approval under the amended *Native Vegetation Regulation 2013* (subject to proposed conditions)

2013 Major wildfire destroys 80 per cent of the Warrumbungle National Park

1950

Good rainfall encourages prolific white cypress pine regeneration event - **1950s cohort**

1950s Livestock grazing withdrawn from State Forests

1964 Extensive culling of eucalypts in white cypress pine forests. Ringbarking replaced by frilling and poisoning. Thinning of white cypress pine to promote growth.

1970

1970s White cypress pine spacing refined to 6 x 6 metres with a minimum of two trees (ironbark and other eucalypts) per hectare retained for wildlife habitat

1980s Livestock grazing returned to State Forests under occupation permits

Thinning of dense white cypress pine regeneration with brush cutters in state forests

1982-83 Cessation of ringbarking and poisoning of eucalypts in state forests

2000

2000 Ironbark sleeper cutting ends

2005

Brigalow Community Conservation Area was established, creating a multiple-use reserve out of what were previously predominantly State Forests.

2013

The structure and composition of white cypress pine woodlands has been influenced by past management for timber values, as well as the interaction of climate with grazing and fire events (**Figure 11**).

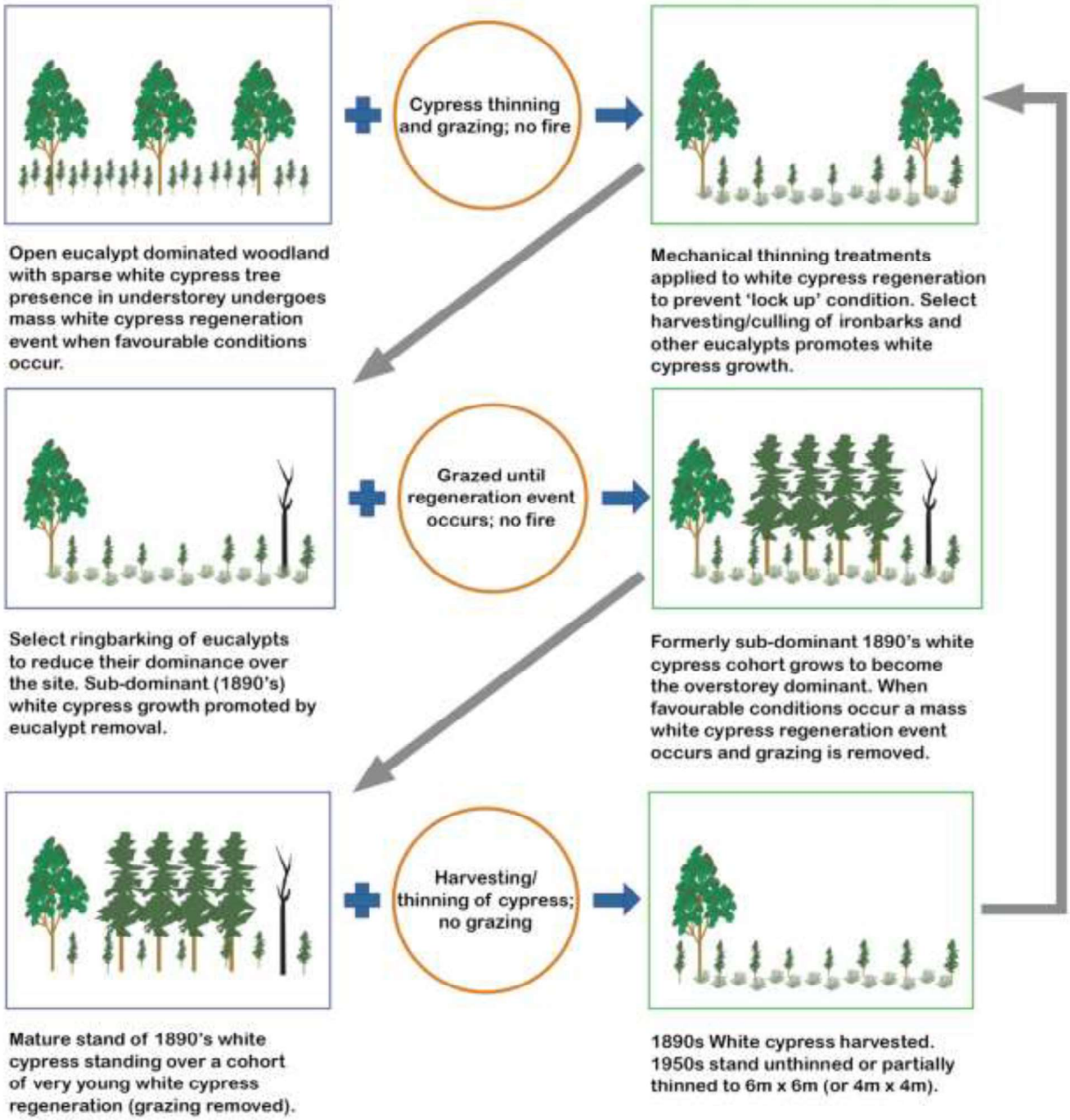

Figure 11: Generalised model of the structure and composition of Australian temperate woodland types with white cypress pine following European settlement

Multiple stakeholder submissions have provided anecdotal accounts of the expansion of dense white cypress pine in the landscape. In some parts of the State Conservation Areas, the shift towards white cypress pine-dominated plant communities – combined with the suppression of fire, periods of reduced grazing pressure and favourable climatic conditions – could have allowed discrete areas of dense white cypress pine to become established. **Figure 12** shows an example of dense white cypress pine regeneration.

Figure 12: Dense stand of white cypress pine regeneration

Dense regeneration is a common feature of the white cypress pine ecology within Australian temperate woodlands, and is controlled by mechanisms such as rainfall, grazing, fire, canopy competition and the health of the mature stand (Lacey, 1972; Thompson & Eldridge, 2005a, 2005b). **Figure 13** provides a generalised model of dense white cypress pine regeneration.

Regeneration events are highly episodic, and require periods of suitable conditions including:

- one or two years of wet summers, below−average temperatures and ample autumn−winter rainfall for at least one season
- a sufficiently open canopy
- an absence of fire and grazing (Lacey, 1972; Nicholson, 1997; Ross et al., 2008).

Significant regeneration events occurred in the 1890s, 1950s and from 1974 onwards (Allen, 1998). For instance, regeneration was able to occur in the 1890s as grazing pressure was reduced due to the removal of stock during a period of economic depression (Rolls, 1981). Similarly, the introduction of myxomatosis in the 1950s reduced grazing pressure from rabbit populations at the same time as suitable climatic conditions occurred for regeneration, leading to the 1950s white cypress pine regeneration cohort (Rolls, 1981). In many areas, this has resulted in a 'two-tier' forest structure of 1890s and 1950s regrowth (Knott, 1995).

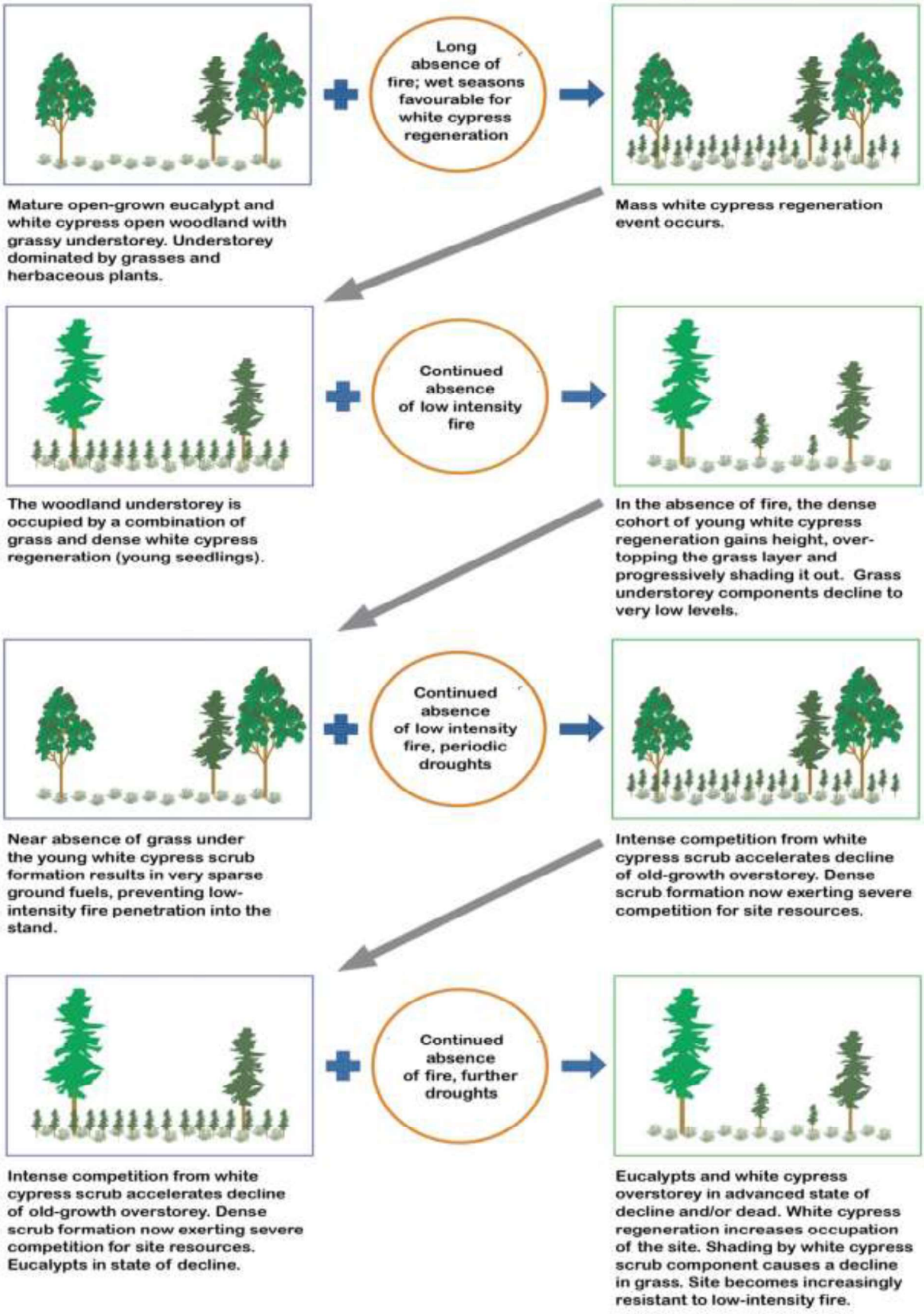

Figure 13: Generalised model of the structure and composition of Australian temperate woodland types with dense white cypress pine regeneration

Given the right conditions and an absence of control mechanisms, white cypress pine regeneration can establish large, dense stands that persist over long periods of time (up to 100 years) as it is highly tolerant of competition and drought, can recruit in large numbers and lacks mechanisms for rapid self-thinning (Horne & Robinson, 1987; Knott, 1995; Lacey, 1972; Lunt et al., 2011). In this so-called 'locked-up' state, competition for resources prevents any significant growth in height or diameter (Horne, 1990; Knott, 1995; Thompson & Eldridge, 2005b). For example, stands dating from the 1950s can today support densities from 10,000 to more than 100,000 stems per hectare, with heights as low as 3–5 metres (Horne & Robinson, 1987; Lacey, 1972).

Box 1: Defining density thresholds in white cypress pine stands

Previous studies have used a range of different criteria to define density thresholds for white cypress pine populations, including when:

- tree basal area[16] is greater than 18 cubic metres per hectare (Lacey, 1973)
- trees reach 1,500 stems per hectare (McHenry et al., 2006)
- tree stems are from 10,000 to in excess of 100,000 stems per hectare, with tree heights as low as 3 to 5 metres (Ross et al., 2008)
- tree stems are between 420 and 748 stems per hectare (Lindsay, 1946)
- seedlings are from 6,000 to in excess of 500,000 per hectare (Horne, 1990)
- tree cover reaches between 50 and 75 percent of a sample area, and tree diameter at breast height is greater than 10 centimetres (Hunter, 2013)
- trees are between 3 and 6 metres tall, and tree diameter at breast height is less than 3 centimetres (Cohn et al., 2012)
- tree diameter at breast height does not reach 18 centimetres (Turland, 2003)
- tree stems reach 7,000 per hectare (Berney, 2013).

Density thresholds for white cypress pine populations are often determined according to the management objective; however, other factors such as soil fertility levels and rainfall also influence these thresholds. A site with more available nutrients and higher rainfall may be more tolerant of dense stands of white cypress pine and therefore exhibit more resilience (or a higher threshold point) than a site with relatively infertile soils and lower rainfall.

This suggests there may be a need for a range of density threshold definitions depending on ecological management objectives and biophysical variables.

White cypress pine regenerates more prolifically in open conditions with fewer competing plants (Horne, 1990). The canopy of forests is subject to silvicultural operations and is, in general, both sufficiently open to allow for understorey growth and yet dense enough to suppress further regeneration episodes (Lacey, 1973). However, white cypress pine is shade-tolerant and will regenerate under woodland and forest canopies with a basal area below 14 square metres per hectare, though growth may be suppressed to some extent by the competing overstorey species (Lacey, 1972; Lunt et al., 2006; State Forests of NSW, 2000).

16 Basal area is the sum per hectare of the cross-sectional areas of the tree trunks of all live trees, measured at a height of 1.3 metres.

The trends discussed above are also supported by Whipp et al. (2012) who studied changes in the Pilliga forests over the last 60 years. This study focused on white cypress pine, bulloak (*Allocasuarina luehmannii*) and narrow-leaved ironbark (*Eucalyptus crebra*) and concluded that:

- the mean density of all species was 3,638 stems per hectare, and 86 percent of these stems were either white cypress pine or bulloak
- there was around a three-fold increase in density, and about a four-fold increase in the basal area for each species over the last 60 years
- the density of white cypress pine saplings doubled in the same period
- the increase in white cypress pine density was largely due to the 1950s regeneration event (Whipp et al., 2012).

6.4 Potential impacts of landscape changes on white cypress pine

6.4.1 Potential impact of shift from eucalypt to white cypress pine

Shifts from eucalypt to white cypress pine-dominated vegetation communities have significant effects on the fauna that rely on eucalypts, as white cypress pine and eucalypt support different habitat values (Lunt et al., 2006). For example, studies have shown areas with large overstorey eucalypts tend to support more cover and diversity of shrubs, potentially due to increased nitrogen and carbon from leaf litter, increased water infiltration and use of the canopy by birds for perching, leading to more seed dispersal (Thompson & Eldridge, 2005a).

Eucalypt species are an important resource for native fauna, offering ecological value in the form of hollows for shelter and nesting, and nectar provision for food (Cameron, 2006; Gibbons & Lindenmayer, 2002; MacNally & MacGoldrick, 1997). The loss of eucalypts since European settlement is likely to have caused a major decline in nectar provision in some areas of NSW (Lunt et al., 2006). White cypress pine provides shelter among branches and bark (for example, for small birds, bats and invertebrates (Adams & Law, 2011; Law et al., 2011; Thompson & Eldridge, 2005b) and supports some nesting birds such as the speckled warbler (*Sericomis sagittatus*) (Shelly, 2013; Thompson & Eldridge, 2005b). However, white cypress pine does not produce nectar and rarely forms hollows (Bennett, 2003a).

The presence and size of eucalypts is a strong predictor of hollow occurrence and abundance (Rayner et al., 2014; Whipp et al., 2009). The ability of species to move between hollows may serve to reduce parasite infestation, minimise risk of predation, provide appropriate thermal microclimates and allow energy-efficient access to foraging areas (Lewis, 1995).

Large hollows take over a century to develop and are rare in eucalypt trees that have established since European settlement (Gibbons & Lindenmayer, 2002). However, there are limited old growth elements in some State Conservation Areas (NSW National Parks and Wildlife Service, 2012d). The loss of eucalypts since European settlement is likely to have caused a major decline in hollow and nectar provision in some areas of NSW (Lunt et al., 2006). Further, the hollow-bearing trees that currently remain in the landscape will be gradually lost over time, for example through fire or decay. Once these hollows are lost, there may be fewer new hollows forming to replace them (Parnaby et al., 2011).

6.4.2 Potential impact of large dense white cypress pine stands

There is debate around the impact of dense white cypress pine on ecological values, balancing the potential negative impacts of large stands of dense white cypress pine that lack structural diversity with the screening and habitat value of smaller dense cypress stands within a vegetation mosaic.

Large stands of woody vegetation can impact broad biodiversity values over time and space (Ayers et al., 2001; Noble, 1993). Large stands of structurally homogenous white cypress pine are thought to reduce spatial variability and habitat values in some forests, particularly where eucalypts have been replaced as the dominant species (Lunt et al., 2006).

Further, dense woody vegetation is known to have a negative impact on canopy trees (Barnes & Archer, 1999; Callaway & Walker, 1997; Noble, 1993). Woody vegetation increases competition for resources and can accelerate mortality of canopy trees (Belsky & Blumenthal, 1997). For example, drought affects eucalypts more severely than white cypress pine (Jurskis, 2011, 2009; Lacey, 1972), while white cypress pine in the overstorey is more affected by drought than white cypress pine regeneration (Cohn et al., 2012; McHenry et al., 2006).

A commonly held view is that dense stands of white cypress pine reduce groundcover and floristic diversity (Horne, 1990; Lacey, 1972). In stands of dense white cypress pine, it has been suggested that species composition in the understorey changes (McHenry et al., 2006). Trees, shrubs and hemi-parasites[17] decrease most likely due to competition for resources such as space, nutrients, light and water (Hunter, 2013; McHenry et al., 2006). However herbaceous and non-vascular plants such as mosses, lichens and liverworts may increase under these conditions (Thompson & Eldridge, 2005b).

Other studies have challenged assumptions around the impact of dense white cypress pine on species richness, suggesting that canopy density does not have a clear impact on species richness or degraded ecosystems (Eldridge et al., 2011; Hunter, 2013; Thompson & Eldridge, 2005a), and that rainfall and disturbances like grazing are key drivers of species richness (McHenry et al., 2006).

Large stands of dense white cypress pine are also likely to have less social and recreational value than more floristically and structurally diverse areas of forest that provide favourable fauna habitat. Anecdotally, stakeholder submissions also indicated that dense stands of white cypress pine are believed to harbour more pests and weeds. For instance, the NSW Farmers submission indicated that "farmers regularly report smaller tree sizes and increased number of feral pests, combined with a decline in native wildlife and no useful groundcover".

On privately managed land within the Brigalow and Nandewar region, NSW native vegetation regulations allow dense stands of white cypress pine to be cleared as invasive native scrub. These regulations were put in place on the basis that "dense stands of invasive native scrub reduce habitat and can lead to increased potential for soil erosion, changes to soil surface hydrology and a change in biodiversity as a result of reduced groundcover"(NSW Office of Environment and Heritage, 2006).

Despite these debates, there is a strong consensus in the scientific literature that vegetation mosaics and their associated habitats are critical in supporting regionally diverse native flora and fauna, and ecological processes at different scales (Hobbs, 1999; Lambeck & Saunders, 1993;

17 A plant that both obtains nutrients from its host and photosynthesises; for example, mistletoe.

Law & Dickman, 1997; Lindenmayer & Franklin, 2002; McIntyre & Barrett, 1992). Some species require dense areas of vegetation, whereas others prefer less dense areas or open grasslands (Adams & Law, 2011; Ayers et al., 2001; Daly & Hodgkinson, 1996; Law et al., 2011). Studies indicate that dense white cypress pine stands can provide screening for fauna against predation at the stand scale (Shelly, 2013). This illustrates the importance of retaining some stands of dense white cypress pine within the landscape mosaic.

The NRC has previously recognised that small patches of dense white cypress pine regeneration can provide important habitat within a landscape mosaic (Natural Resources Commission, 2010b). However, large areas of dense, structurally homogenous white cypress pine in the State Conservation Areas are less likely to support ecological values than a landscape containing mosaics of different vegetation types and spatial diversity of vegetation structures.

For this reason, the NRC supports the hypothesis that some large stands of dense white cypress pine should be actively managed to provide a more structurally and floristically diverse habitat mosaic within the State Conservation Areas. However, assumptions around the positive ecological impact of managing large dense white cypress pine stands, as well as uncertainties around the optimum range of patch sizes for dense white cypress pine, should be tested within an adaptive management framework to reduce remaining uncertainty and knowledge gaps around the active management of dense white cypress pine for ecological outcomes.

On the basis of the discussion in this chapter, the NRC has invested in spatial analysis to understand how widespread the identified issues with large dense white cypress pine stands are within the State Conservation Areas. The results of this analysis are present in the following chapter (**Chapter 7**).

7 Assessing white cypress pine in the State Conservation Areas

Key points

KP 7.1 Over half the land covered by State Conservation Areas has little or no white cypress pine or low canopy densities.

KP 7.2 However, there are some large areas of white cypress pine (greater than 500 hectares) especially in some of the larger State Conservation Areas such as Goonoo, Pilliga, Pilliga West, Trinkey and Pilliga East.

KP 7.3 In five State Conservation Areas white cypress pine exhibited a relatively low cover and generally uniform height distribution throughout forests, while non-cypress species possessed a higher cover and more variable height distribution.

This chapter describes the key results from the NRC's analysis of the presence and distribution of white cypress pine in the State Conservation Areas.

To better understand the distribution of white cypress pine together with forest structure in the State Conservation Areas, the NRC completed spatial and statistical analyses that added value and generated new knowledge from two independent datasets. These included using:

1 ADS40 imagery[18] to detect specific spectral signatures of white cypress pine and then classify and characterise the extent, distribution and density of white cypress pine across all of the State Conservation Areas

2 LiDAR[19] data to describe the structure and composition of vegetation in five sample State Conservation Areas

The spatial analysis also helped the NRC to identify potential areas of management concern (**Chapter 9**), and potential economic and social costs, benefits and impacts from implementing active and adaptive management (**Chapters 11** and **13**).

The NRC selected existing ADS40 imagery as the primary data source for spatial analysis because it enabled a consistent, objective and cost-effective approach across all State Conservation Areas. The NRC investigated remotely-sensed SPOT 5 satellite data but found it could not adequately detect and classify white cypress pine. LiDAR data extended the ADS40 analysis by providing more detail on tree heights and stand structure. However, capturing new LiDAR data across all the State Conservation Areas was cost prohibitive, so LiDAR data was captured over five State Conservation Areas rather than 23.

Attachment 3 provides additional information on the NRC's spatial analysis, including the data and methodologies used to inform the review. Detailed results and relevant mapping for

18 Digital Image Acquisition System (ADS40) - high resolution digital aerial photography collected using a second-generation airborne digital camera (Maguire et al., 2012) that captures RGB band at 50 centimetre pixel resolution.

19 LiDAR (Light Detection and Ranging) is a technology that uses laser pulses to generate large amounts of data about the physical layout of terrain and landscape features (CSIRO, 2014). This data was collected in Bobbiwaa, Killarney, Merriwindi, Pilliga West and Trinkey State Conservation Areas.

individual State Conservation Areas can be found in the NRC's *Draft report supporting profile and map book*.[20]

7.1 Assessing white cypress pine density and distribution

The NRC used presence and extent mapping based on ADS40 imagery to develop maps to identify areas where there are likely to be more or less dense white cypress pine stands across all State Conservation Areas (and example is provided in **Figure 14**).

The NRC then categorised these maps into five cypress canopy percentage classes, based on the percentage area covered by white cypress pine crowns[21]. **Figure 15** illustrates the cypress canopy percentage classes, while **Figure 16** shows on-ground examples of the classes. **Figure 17** provides an example of the NRC's cypress canopy percentage class mapping for Bobbiwaa State Conservation Area.

The NRC found the canopy density classes were consistent with the frequency of density estimates in field survey data (**Attachment 3**). This indicative measure for white cypress pine density allowed areas to be calculated in spatial software as a useful way of assessing the 'patchiness' of the vegetation and identifying potential areas of dense cypress.

These classes are indicative of areas where white cypress pine canopies are present at lower or higher density levels, but do not provide precise measures of actual stem densities. Nor do they provide the total canopy cover of all species. For example, while classes 0 and 1 show little or no white cypress pine or a small proportion (1-10 percent), the actual area could contain many other species of various densities. It is important to note that the canopy coverage of white cypress pine may be underestimated where small white cypress trees are located under larger white cypress trees and overestimated where bulloak is present (see **Section 7.2.1**).

The spatial methodology used to group white cypress pine into cypress canopy percentage classes has in effect defined a 'patchiness' layer for white cypress pine within the landscape that is a useful measure to understand the need for active management. In practice, this 'patchiness' of white cypress pine exists within contiguous vegetation, rather than the more familiar discrete vegetation patches within a fragmented agricultural landscape.

The NRC ground-truthed this spatial analysis (**Attachment 3**) and is confident that these classes are a useful way of identifying potential areas that contain white cypress pine with different densities and assessing the 'patchiness' of the vegetation. This analysis including maps of the cypress canopy density classes (**Figure 17**) also provide a useful benchmark of the current situation for future monitoring.

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20 Booklet available online at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx

21 The percentage coverage was calculated based on the proportion of the total area (in this case, a 0.26 hectare moving window, or 'search area' in the spatial software) covered by pixels identified as containing white cypress pine (each pixel represents 50 centimetres by 50 centimetres on the ground). The NRC allocated Class 4 as the ceiling class (where cypress densities are greater than 31 percent), as there were only limited areas in State Conservation Areas where the number of pixels that contain white cypress crowns were greater than this amount. The NRC considers these threshold classes to be readily understood, that they provide adequate distinction and can be readily aggregated and disaggregated.

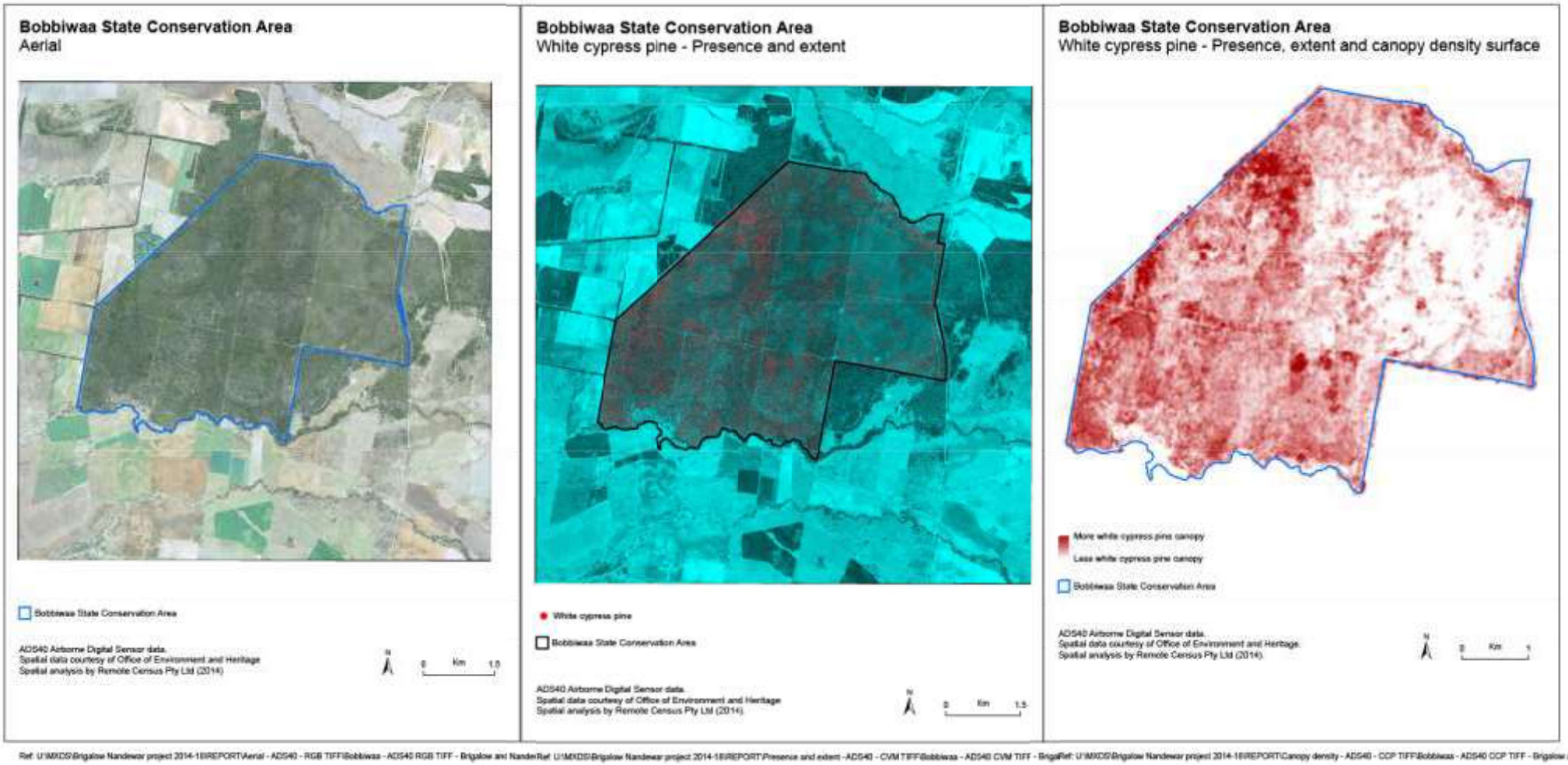


Figure 14: Steps in the spatial analysis of ADS40 imagery. The original ADS40 image (left figure) was converted into a presence and extent layer (middle figure) and a white cypress pine canopy density (right figure) that shows where white cypress pine canopy is more or less dense

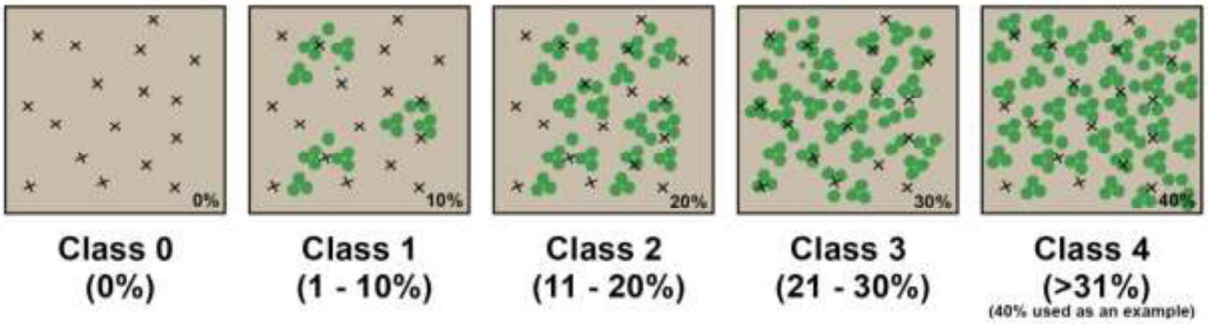


Figure 15: Illustration of the white cypress pine canopy across five density classes

Green circles show indicative cypress canopy percentage for each class and the black crosses represent other species. The number of black crosses is *not* indicative of the canopy percentage for other species as the spatial methodology did not classify the canopy percentage for other species.

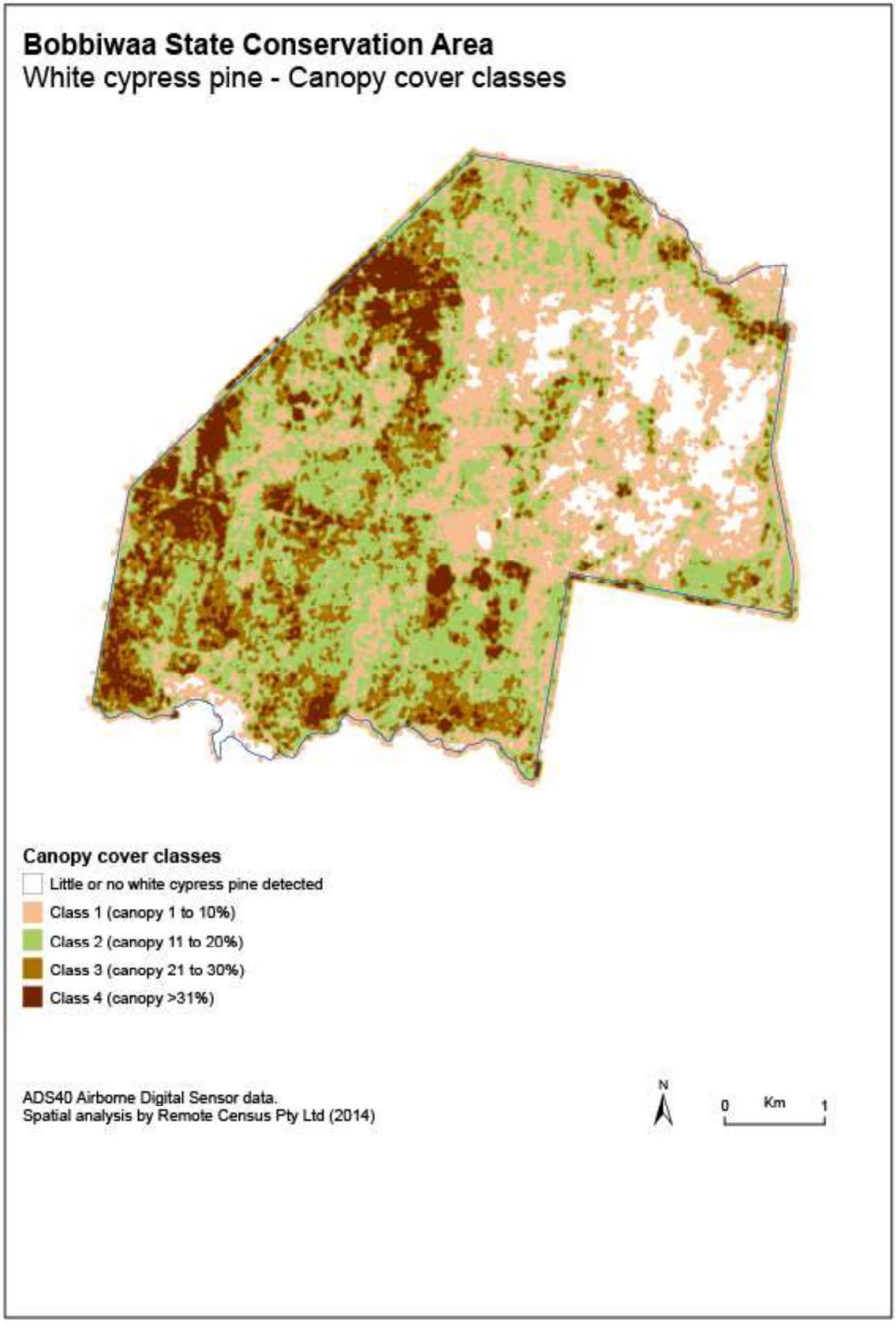
Cypress canopy percentage class 1
(Pilliga West State Conservation Area)

Cypress canopy percentage class 2
(Merriwindi State Conservation Area)

Cypress canopy percentage class 3
(Pilliga West State Conservation Area)

Cypress canopy percentage class 4
(Pilliga West State Conservation Area)

Figure 16: On-ground examples of cypress canopy percentage classes 1 – 4



Ref: U:\MXDS\Brigalow Nandewar project 2014-18\REPORT\Canopy cover - ADS40 - CCP SHAPE\Bobbiwaa - ADS40 CCP - Brigalow and N

Figure 17: Cypress canopy density classes in the Bobbiwaa State Conservation Area

The NRC's analysis of cypress canopy percentage classes across all 23 State Conservation Areas and found that:

- over half the total area has little or no white cypress pine or low canopy densities (i.e. classes 0 and 1) (
- **Table 10**)
- the vast majority of white cypress pine classes (or patches) are less than one hectare but that only account for around 8 percent of the total area of white cypress pine (**Table 11**)
- 74 patches of white cypress pine are greater than 500 hectares in size and account for over half of the total area of all State Conservation Areas (54 percent) (**Table 11**)
- Goonoo, Pilliga and Pilliga West have the highest number of white cypress pine areas greater than 500 hectares, followed by Trinkey and Pilliga East (larger areas of white cypress pine tend to be in the larger State Conservation Areas)
- nearly all (99.8 percent) of the most dense white cypress pine areas (class 3 and class 4) are found in patches less than 20 hectares in size (**Table 11**).

Table 10: Summary of white cypress pine canopy density analysis across all State Conservation Areas

Class	Total area (hectares)	Number of patches
Class 0 (little or no white cypress pine detected)	22,776	NA
Class 1 (1-10 percent)	83,337	70,389
Class 2 (11-20 percent)	51,182	93,041
Class 3 (21-30 percent)	22,966	81,296
Class 4 (greater than 31 percent)	12,824	44,450
Total	193,085	289,176

Table 11: Analysis of white cypress pine patch size

White cypress pine patch size (hectares)	Total area (hectares)	Number of patches
Less than 1	13,311	281,890
1-20	23,348	6,720
21-50	8,738	280
51-100	6,569	93
101-500	26,796	119
501-1000	31,328	45
Greater than 1001	60,219	29
Total	170,309	289,176

7.2 Assessing vegetation stand structure

The NRC has used LiDAR data to analyse and describe stand structure and variability of vegetation across five State Conservation Areas.[22] LiDAR delivers information about the structure and composition of vegetation by providing a three-dimensional profile of the canopy; including the height and shape of individual trees in a forest stand.

Given that the NRC's white cypress pine density analysis is primarily based on existing ADS40 data, LiDAR analysis was limited to five State Conservation Areas to reduce the costs associated with capturing new LiDAR data.

Key findings from the LiDAR analysis across all five State Conservation Areas are that:

- white cypress pine exhibits a relatively low cover and generally uniform height distribution, while non-cypress species has a much higher cover and more variable height distribution
- there is little white cypress pine under 3 metres in height (sometimes referred to as cypress regrowth or regeneration)[23]
- the white cypress pine component of the forests exhibits a reasonably uniform structure, with almost all areas exhibiting an average cover of between 1 and 10 percent for trees within height bands below 22 metres, and a cover of less than 1 percent for trees above 22 metres.

Overall, the analysis suggests the forests in these five State Conservation Areas support mixed-aged stocking of white cypress pine within an overall stand structure in which eucalypts and other non-cypress species generally have a much higher cover than cypress in most areas.

Additional details on the methods used to conduct this LiDAR analysis are available in **Attachment 3**. Further results of this analysis are available in the *Draft report supporting profile and map book*.[24]

7.2.1 Reliability of the ADS40 and LiDAR analysis

Spatial analysis allows for a complete census, in this case of all white cypress pine tree canopies in all State Conservation Areas, rather than the traditional approach of describing vegetation characteristics from samples alone. Census avoids problems with sampling design and execution, inference, and error projections that are common in field assessments.

The confidence levels associated with the spatial analysis in this review are shown in **Table 12**. These were arrived at by comparing field samples with image classifications and modelled estimates. Previous inventories of white cypress pine volume across the Brigalow and Nandewar using sampling techniques had an estimated confidence interval of plus or minus 30 percent (Baalman, 2003).

The creation of cypress canopy density classes should be considered as a preliminary first step 'meta-analysis' and further work should be undertaken to fully exploit the ADS40 and LiDAR data over some of the State Conservation Areas. It is important to note that the cypress canopy density classes derived from the ADS40 analysis locate white cypress pine and show where it is

22 Bobbiwaa, Killarney, Merriwindi, Pilliga West and Trinkey State Conservation Areas.

23 This height band was modelled as LiDAR data was not captured on trees below 3 metres.

24 Booklet available online at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx

relatively more or less dense in the State Conservation Areas. The cypress canopy classes cannot reliably predict attributes such as stem densities and basal area without further survey stratification (for example, by forest type) and field sampling.

Nevertheless the NRC considers the spatial data analysis approach undertaken for this review is sound and fit for the purposes to meet the terms of reference for this review.

Table 12: Reported accuracies and reliability of methods

Spatial analysis	Key measures and products	Confidence level[25]	Reference
ADS40 (~196,000 hectares)	▪ White cypress pine identification	**87%** (average)	(Eco Logical Australia, 2014) (Attachment 3)
	▪ Cypress canopy percentage classes	**73%** (average)	(Eco Logical Australia, 2014) (Attachment 3)
ADS40 + LiDAR (~29,000 hectares)	▪ Vegetation classification	**75%**	(Forestry Corporation of NSW, 2013) (Attachment 3)
	▪ Standing timber modelling	**90%**	(Forestry Corporation of NSW, 2014) (Attachment 3)

[25] Proportion of observed measures consistent with expected or predicted values.

8 Managing risks and uncertainty around future trajectories

Key points

KP 8.1 The NRC's spatial analysis around the current distribution of dense white cypress cannot predict future trends in the extent of dense white cypress pine. However, recent scientific studies suggest that the extent and density of white cypress pine is likely to expand in the future. Other studies suggest natural thinning in white cypress pine forests can take up to 300 years.

KP 8.2 The NRC developed a model showing a suggested future trajectory in which resource competition from dense white cypress pine stands would continue to exert pressure on eucalypt growth and habitat values.

KP 8.3 Should the forests follow this trajectory, natural processes and current management approaches are unlikely to alter this path or mitigate the associated ecological impacts. Instead, interventions to manage large areas of dense white cypress pine should be implemented within at-risk areas, using an adaptive management approach to manage risk and support a structured learning process.

KP 8.4 The NRC's spatial analysis provides an important benchmark and approach for monitoring any future change.

In determining what management interventions, if any, may be needed in the State Conservation Areas, the future trajectory of the landscape under current management must be considered. The impacts and trade-offs associated with management interventions must be weighed against the risks involved if landscapes continue along their current paths.

8.1 Potential future trajectories and risks

The NRC's analysis characterises the extent and distribution of white cypress pine in the State Conservation Areas, providing a snapshot of the current situation. While the evidence from this analysis suggests that the extent of vegetation is relatively heterogeneous at this point in time, some larger areas of white cypress pine have been identified that may be at risk of the negative ecological impacts described in **Section 6.4**.

While the NRC's analysis characterises the current situation, evidence around potential future trajectories is less certain. For example, it is difficult to determine whether the extent of cypress canopy percentage classes (in particular the classes containing higher density white cypress pine canopies) will expand based on this analysis alone.

In practice, dense white cypress pine stands and patches are likely to expand and contract under the influence of different natural disturbances and management activities. As such, the NRC analysis provides an important benchmark to monitor any future change.

However, recent studies suggest that the extent and density of white cypress pine is currently expanding, and is likely to expand further in the future.

For example:

- Cohn et al. (2012) suggest that over time white cypress pine saplings are likely to replace eucalypt canopy trees, further increasing white cypress pine dominance in semi-arid areas compared to eucalypts
- Whipp et al. (2012) suggest forest encroachment and the expansion of dense white cypress is continuing in the Pilliga and observed:

> *"the high density of Callitris saplings in both forest types[26] suggests that stand structure may change greatly in the future, depending on disturbance regimes [and] unless thinned mechanically or by fire, locked stands of dense small Callitris are likely to form in both forest types, and earlier difference between the two forest types are likely to disappear."*

Figure 18 shows a potential indicative future state in a eucalypt-white cypress pine forest system. In this scenario dense stands of white cypress pine persist in discrete areas across the landscape, with limited growth due to competition within the stand (Lacey, 1973). Resource competition from dense white cypress pine stands would continue to exert pressure on eucalypt growth, with hollow formation also being reduced (Cohn et al., 2012).

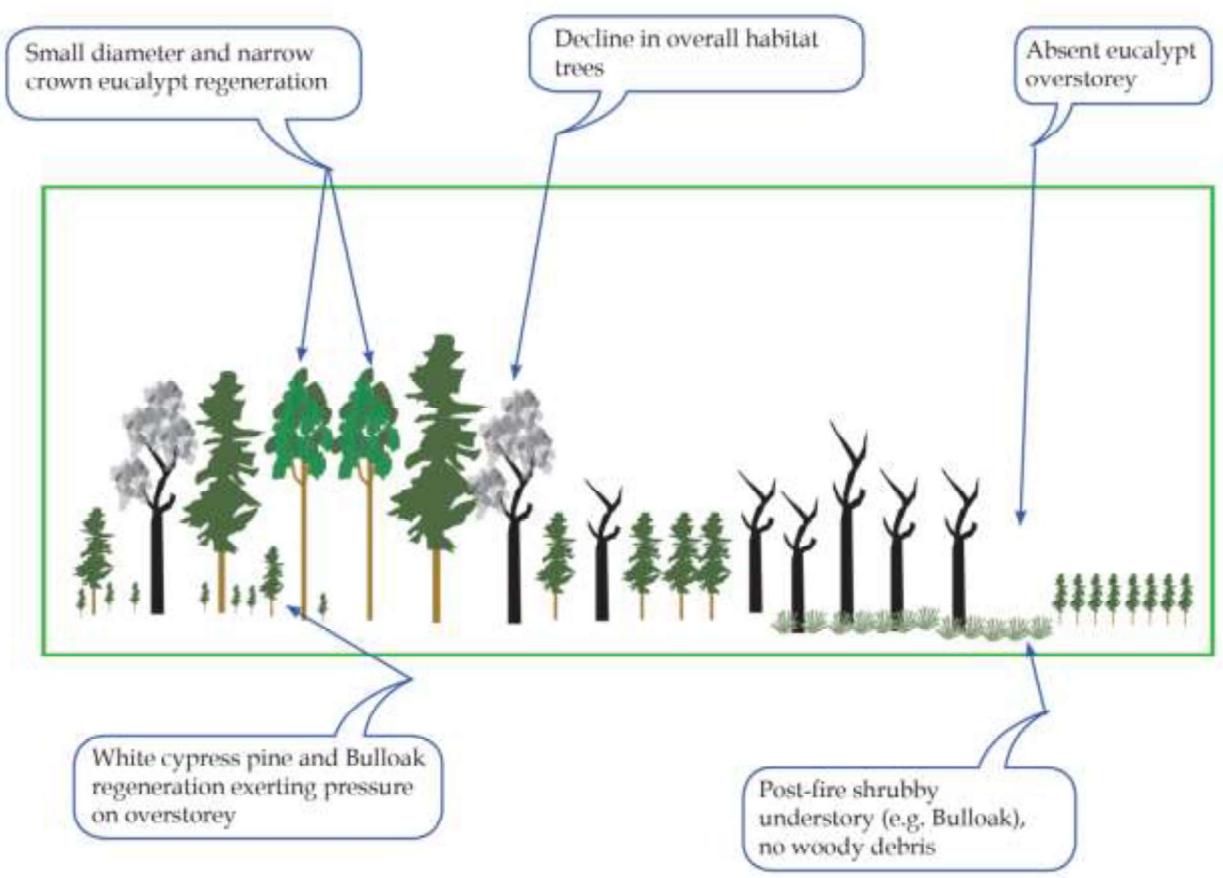


Figure 18: Indicative future state in a eucalypt-white cypress pine forest system

The full extent of the impacts of an increase in white cypress pine density on environmental values in the State Conservation Areas will only be realised in time. For example, as tree

[26] Forest types based on Lindsay forest type classifications (Lindsay, 1967). The two forest types are PCO (white cypress pine – narrow-leaved ironbark – forest oak) and COP (narrow-leaved ironbark – forest oak – white cypress pine).

hollows can take up to 100 years to form, this is how long it will take for impacts from reduced recruitment of eucalypts to occur (Gibbons & Lindenmayer, 2002). This habitat resource is likely to diminish over time as younger trees that would have matured to replace the current stock of hollow bearing trees were depleted in the past (Parnaby et al., 2011). Further, natural thinning processes operate on extremely long timeframes. For example, it could take up to 300 years for natural thinning to occur in dense white cypress pine forest (Kerle 2005, after Allen 1998).

8.2 Managing uncertainty and risks

The historical and scientific debate around past and future landscapes, and around potential risks to environmental values from dense white cypress pine, demonstrates both the need and an appropriate context to apply active and adaptive management in the State Conservation Areas (refer to previous discussion in **Chapter 5**).

The current plans of management do not apply a best practice approach to adaptive management (as described in **Section 5.1.2**). The potential for dense stands of white cypress pine to impact forest structural diversity and habitat values is not addressed within the plans, nor are issues around the change in the ratio of eucalypts to white cypress pine within the canopy. As a result, interventions to manage white cypress pine (for example, ecological thinning) are not part of the current management strategy for these areas, although the *Brigalow and Nandewar Community Conservation Area Agreement 2009* for non-commercial ecological thinning to meet strategic management objectives.

The approach to white cypress pine management within the State Conservation Area plans of management differs from the management of white cypress pine on private land. On private land, dense white cypress pine is classed as an invasive native species or a species that forms part of a vegetation formation suitable for thinning (NSW Government, 2014a). As such, it can be managed via clearing or thinning as a routine agricultural management activity. Under the draft Ministerial order for thinning of native vegetation, thinning is defined as:

> *"the selective removal of individual trees and woody shrubs for the purposes of: reducing competition, allowing for improved growth and maturation of retained trees and encouraging regeneration and recruitment"*

Although the outcomes of interventions such as thinning and grazing are well understood in a silvicultural context (Knott, 1995), adaptive management will help address remaining uncertainties around the relative effectiveness of different interventions for delivering ecological outcomes. For instance, some studies indicate that the response of white cypress pine to thinning is not uniform across the landscape, and that in parts of western NSW thinning may not necessarily encourage increased growth and regeneration of eucalypts (Cohn et al., 2012).

Managers should be able to apply interventions within the State Conservation Areas – such as ecological thinning and targeted grazing – in at-risk areas to meet specified ecological objectives, consistent with the provisions of the *Brigalow and Nandewar Community Conservation Agreement 2009.* These interventions should be trialled using an adaptive management approach, to manage risk and support a structured learning process.

The following chapter (**Chapter 9**) provides a high-level outline of several management objectives and management options that might be appropriate for active and adaptive management within the State Conservation Areas in the context of white cypress pine management issues discussed in this report.

9 Maintaining ecological values though active and adaptive management

Key points

KP 9.1 The NRC proposes that an overarching management goal for the State Conservation Areas should be to actively enhance landscape function, ecological processes and natural diversity of the land to support the community's values .

KP 9.2 The goal should be supported by additional management objectives with an explicit emphasis on maintaining, and enhancing where necessary, current forest health in respect to dense white cypress pine to support current and future environmental values.

KP 9.3 The NRC has used process models to develop a decision support framework to help land managers explore management issues and options associated with larger areas of denser white cypress pine.

KP 9.4 Using the decision support framework, the NRC has spatially identified over 57,000 hectares (or 30 percent of all State Conservation Areas) that could be considered as areas of management concern due to relative larger areas of denser white cypress pine. Of this area Goonoo, Pilliga, Pilliga West and Trinkey State Conservation Areas contain the largest areas of management concern.

Draft recommendations

5(a) The NRC recommends the Adaptive Management Plan includes specific, measurable and spatially explicit management targets.

3(b) The NRC recommends that the Office of Environment and Heritage prioritise the development of plans of management for the four State Conservation Areas identified as being priority areas for active management (Goonoo, Pilliga, Pilliga West and Trinkey State Conservation Areas).

In this chapter, the NRC has worked through further elements of the adaptive management framework provided in **Table 7** in relation to the management issues around dense white cypress stands. In particular, this chapter involves:

- specifying management goals and objectives (Element 2)
- documenting a process model for intervention (Element 3)
- identifying areas of management concern.

9.1 Revising the management goal and objectives

Goals are broad, qualitative statements capturing what stakeholders generally agree is the long-term result being sought through management (Slocombe, 1998). Studies have shown that inadequate goal definition is a key barrier to successful natural resource planning (Lachappelle et al., 2003).

The *Brigalow and Nandewar Community Conservation Area Agreement 2009* indicates some of the high level strategic aims for all zones within the Community Conservation Area including:

- managing all land for social, economic and environmental sustainability, based on the principle of inter-generational equity

- maintaining and seeking to improve landscape function, ecological processes and natural diversity of the land
- maintaining and seeking to improve the natural and cultural values of the land (NSW Government, 2009).

Drawing on these high-level aims, the NRC considers a suitable overarching goal for ecosystem management in State Conservation Areas is to:

Actively maintain and enhance landscape function, ecological processes and natural diversity of the land to support the community's values.

The high-level goal should be agreed with regional stakeholders and supported by a suite of objectives that give a better sense of what needs to be done in order to reach the desired end point articulated by the overarching goal.

9.1.1 Additional management objectives

Objectives are more specific, short-to-medium term actions that, when combined, will help achieve the goal (Slocombe, 1998). Land managers should work with technical experts and stakeholders to develop well-defined objectives that are measurable, achievable and able to be prioritised (McAlpine et al., 2013). A series of readily observable and quantifiable targets should nest beneath these objectives to allow managers to track progress and evaluate performance through time (Slocombe, 1998).

Existing plans of management for the State Conservation Areas (NSW Office of Environment and Heritage, 2013e) set out specific management directions, broadly summarised as follows:

- conserve biodiversity and maintain ecosystem function, including restoring native vegetation where necessary
- protect natural values from wildfire, pest and weeds
- protect people and property from wildfire
- protect and conserve cultural values
- provide for research and recreation
- provide for undertaking of other uses such as mining.

A weakness in the current plans is the lack of more detailed information that could help guide management decisions. For instance, the plans do not indicate whether there are any priority values or thresholds of concern within the landscape, nor do they describe the specific habitat requirements of important flora or fauna species and the extent to which these are being provided for under current management.

Without more specific information about values and objectives, supported by measurable targets, it is hard to determine whether the right management strategies are in place or provide accountability around management outcomes (Nicholson & Possingham, 2006).

The NRC is proposing additional objectives that provide new areas of focus for conservation managers based on the management issues identified in **Chapter 6**. These objectives, put forward in **Table 13**, nest under the existing specific management directions, in particular the direction "conserve biodiversity and maintain ecosystem function including restoring native vegetation where necessary".

The NRC's proposed objectives provide more explicit emphasis on maintaining and enhancing overall forest health including vegetation mosaics and structure, recognising:

- the important function that vegetation plays in the landscape by influencing other components of landscape health such as regulation of ecosystem processes, the viability of fauna populations and threatened species, soil health and water quality
- that vegetation is one of the few biophysical elements that land managers can practically actively manage to maintain or enhance desired ecological outcomes.

More specific, measurable and spatially explicit targets should be developed under these proposed additional objectives. Examples of potential targets are also included in **Table 13**.

Table 13: Proposed additional management objectives for State Conservation Areas

	Proposed additional management objectives
Existing management direction: Conserve biodiversity and maintain ecosystem function including restoring native vegetation where necessary	
1	**Maintain and enhance vegetation stand complexity including promoting areas of sclerophyllous shrubs** Example of potential target: *Maintain the proportion of sclerophyll mid-storey by a nominated measure (for example, class or indices per defined mapped area) over a nominated time period (against 2014 baselines).*
2	**Maintain and enhance habitat for fauna, including promoting numbers of eucalypts where necessary** Example of potential target: *Increase the number of tree hollows by a nominated measure (for example, number per defined mapped area) over a nominated time period (against 2014 baselines).*
3	**Reduce stress on trees from resource competition and enhance growth** Example of potential target: Interventions related to this objective are likely to be opportunistic and in very specific areas. Effective monitoring and decision support tools such as the Statewide Landcover and Trees Study (SLATS) vegetation extent map for NSW (for woody vegetation) could be employed to detect stress in tree crowns.
4	**Maintain and enhance groundcover, including diversity** Example of potential target: *Maintain species richness by a nominated measure (for example, biometric indices per defined mapped area) over a 20 year period (against 2014 baselines).*

9.2 Developing and applying a process model

As per Element 3 of the adaptive management framework provided in **Table 7**, the NRC has developed a process model to show the active management options that can be used to achieve the objectives identified in **Table 13**. The process model developed is a state and transition model, as shown in **Figure 19**.

State and transition models document and describe the state of the system, the drivers that can shift transitions between states, and their potential impact on and benefits for ecosystem elements including flora and fauna species (Duncan & Wintle, 2008; Spooner & Allcock, 2006).

Often the development of objectives and models is an iterative, two-way process, whereby information that comes to light through the development of a process model may prompt revision of the initial objectives (NSW Office of Environment and Heritage and Parks Victoria, 2012; Stankey et al., 2005).

9.2.1 Using process models as a decision support framework

The NRC has drawn on the previous state and transition model (**Figure 19**), NRC spatial analysis, existing prescriptions and expert and agency advice to develop a decision support framework as a practical tool to help explore management issues associated with dense white cypress pine. The framework is presented in **Table 14**.

The NRC has used the decision support framework to spatially identify and quantify areas that are likely in acceptable condition to support environmental values (**State I** in the state and transition model), and other areas that may be considered areas of management concern (**State II** and **III** in the state and transition model). The framework and criteria also take into consideration areas with environmental and cultural values, and areas recently impacted by wildfire.

Importantly, the framework is designed to identify areas of management concern, but not to be prescriptive as to how areas of management concern should be addressed. Land managers are likely to be faced with different management scenarios across the State Conservation Areas. In each scenario, decisions around the most appropriate management strategy will be influenced by a unique combination of factors, including the:

- risks and implications of change in a system
- identified management objectives
- extent and configuration of dense white cypress pine, both in the immediate area and within the broader State Conservation Area
- available management resources.

The framework gives land managers the flexibility to choose an appropriate management strategy based on the unique context of a particular location and the comparative cost effectiveness of available options. For example, depending on the area, managers may choose to address class 2 transitional areas in different ways, including:

- through on ground interventions such as ecological thinning – for instance, if these areas are particularly widespread, are adjacent to class 3 and 4 management priority areas, or if management of these areas is more cost effective than intervention in denser stands
- by applying a 'watching brief' – for example, periodically monitoring the area of concern using remote sensing to identify further increases in cypress density and extent over time.

Box 2 outlines rationale and assumptions that underpin the framework in more detail, and provides definitions of key terminology. **Attachment 3** provides more detail on how the spatial data was applied.

Maintaining 'patchiness'

An important driver for the framework is to maintain or enhance 'patchiness', or vegetation mosaics, within the vegetation of the State Conservation Areas so as to support ecological function. The spatial methodology applied to group white cypress pine into cypress canopy percentage classes has in effect defined 'patches' of vegetation that contain white cypress pine within the landscape. As such, these 'patches' of vegetation containing white cypress pine exist within contiguous vegetation.

Much of the current information about patch size relates to patches of vegetation within a cleared landscape, not patches of one vegetation type within a forest or woodland area (Lindenmayer & Fischer, 2006). Factors to consider for patches within a forest matrix include the size and shape of the patch, the distance between patches and the habitat requirements of different species (Helzer & Jelinski, 1999; Priday, 2010).

In the absence of clear thresholds around patch size within contiguous vegetation in the scientific literature, the NRC has adopted a minimum patch size of one hectare in its approach to identifying areas of management concern. This condition has been applied to ensure some dense patches of cypress regeneration are retained within the landscape to maintain a mosaic of different vegetation types. The use of this condition within contiguous vegetation should be tested as part of the adaptive management process, with a view to confirming or refining thresholds around patch size. This patch size condition aligns with conditions in the NSW Government's draft Ministerial orders for thinning native vegetation on private land, which are generally applied to discrete areas of vegetation (NSW Government, 2014b).

Across all State Conservation Areas, patches with an area of less than 1 hectare made up 98 percent of the total number of patches identified in the NRC's analysis, but accounted for less than eight percent of all land within the State Conservation Areas (**Attachment 15**). Larger size patches are more likely to be a priority for active and adaptive management, with smaller patches providing pockets of dense cypress to contribute to landscape diversity.

In reality the canopy cover is highly variable across the landscape. The classes are simply a way to try and help focus on areas of interest, and do not represent discrete entities that will behave differently to the surrounding vegetation. For example, a narrow patch of class 3 (E) between two patches of class 4 (F) might in reality operate in the landscape as a single patch of class 4 (F).

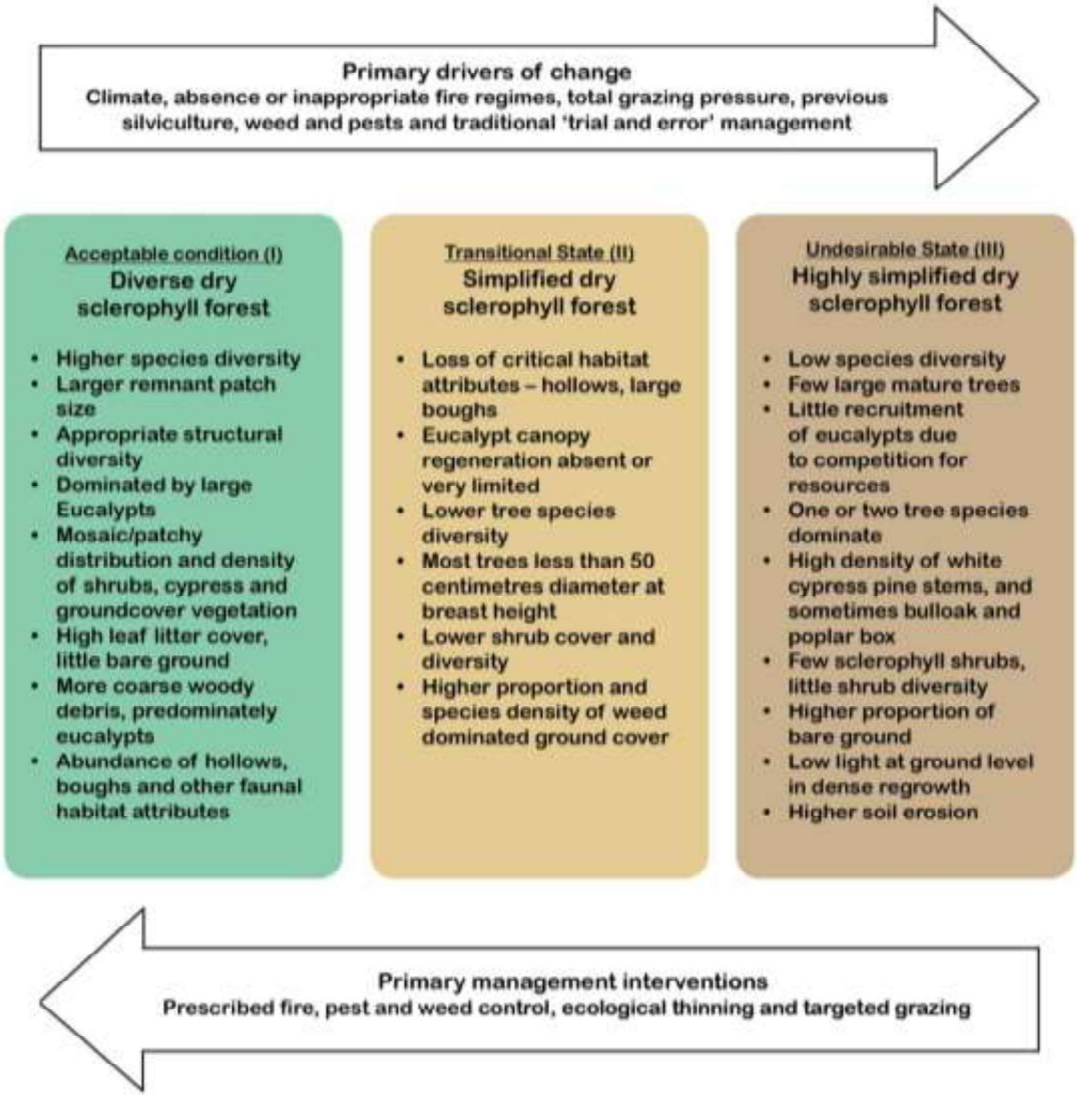


Figure 19: State and transition model for white cypress pine forests

Table 14: Criteria for identifying acceptable condition and areas of management concern

		Criteria	Key rationale
Areas with acceptable condition state (State I)		**A** All areas with little or no white cypress pine detected **B** All cypress canopy percentage classes 1-4 (between 1 and 100 percent canopy coverage) with patch sizes less than 1 hectare **C** Cypress canopy percentage class 1 (1 - 10 percent canopy coverage) with patch sizes greater than 1 hectare	▪ Likely to be within acceptable levels of natural variability occurring at present time ▪ Minimal impact on environmental values ▪ Retains small patches of white cypress pine in the landscape some of them dense
Areas of management concern	**Transitional state (State II)**	**D** Cypress canopy percentage class 2 (11 - 20 percent canopy coverage) with patch sizes greater than 1 hectare	▪ Nearing thresholds of management concern ▪ Impact on future environmental values ▪ Retains small and few larger, more dense patches of white cypress pine in the landscape ▪ Some areas are likely to be more ecologically or culturally sensitive than others
	Undesirable state (State III)	**E** Cypress canopy percentage class 3 (21 - 30 percent canopy coverage) with patch sizes greater than 1 hectare **F** Cypress canopy percentage class 4 (greater than 31 percent canopy coverage) with patch sizes greater than 1 hectare	▪ Crossed thresholds of management concern ▪ Impact on current and future environmental values ▪ Retains small and a few larger, more dense patches of white cypress pine in the landscape ▪ Some areas are likely to be more ecologically or culturally sensitive than others

Notes:

- All areas reported for classes in the areas of acceptable condition (A, B and C) **include** sensitive environmental and cultural areas, and areas that have had recent wildfires.
- All areas reported for classes in the areas of management concern (D, E and F) **exclude** sensitive environmental and cultural areas, and areas that have had recent wildfires.

Box 2: Definitions, rationale and assumptions

The NRC used presence and extent mapping based on ADS40 imagery to develop maps and classes showing where there are likely to be more or less dense white cypress pine stands across all State Conservation Areas. The classes do not provide precise measures on actual stem densities.

The areas defined as 'likely area with acceptable condition' (State I in the state and transition model) for the system have lower canopy cover at present, and thus likely to contain lower stem densities of white cypress pine. Conservation land managers may consider these areas to have acceptable levels of natural variability between system boundaries occurring within them at the current time.

The areas of management concern are divided between transitional and undesirable states, based on the assumption that class 2 areas may transition into being class 3 areas at some point in the future (**Figure 19**). It is important to note that the dotted lines in **Table 14** represent potential boundaries or thresholds of concern between classes – in practice these are not hard boundaries, but have been applied here to assist in high-level analysis of management issues.

As **Section 5.1.2** explained, the exact tipping point between various states of condition in many natural ecosystems is not known. The NRC could not find any specific scientific evidence to precisely define boundaries used for transitional and undesirable states set out in **Table 14**. For example, there is no agreed threshold to define 'locked-up' white cypress pine stands particularly in the context of land managed primarily for conservation purposes (**Box 1**). As a result, the transitional boundaries the NRC has applied are arbitrary.

The primary assumptions for areas defined as areas of management concern are:

- **transitional state** (**State II** in the state and transition model) are areas where canopy cover is transitioning between lower and higher canopy cover (and hence, stem densities). Conservation land managers may consider white cypress pine canopy cover in these areas may be approaching a point where environmental values are at an unacceptable risk in the future.
- **undesirable state** (**State III** in the state and transition model) have higher canopy cover, and thus likely to contain higher stem densities of white cypress pine. Conservation land managers may consider these areas have transformed from previous areas of acceptable condition, and place environmental values potentially at risk.

Similar ideas about transformations in white cypress pine forests have been previously reported. Whipp et al. (2012) found white cypress pine densities increasing in the Pilliga[27] based on comparisons between forest type mapping in the 1940s and data from field surveys in 2005. In effect, the study illustrated a transformation between stem densities and forest types over a certain time period. The authors concluded forest encroachment and increased densities – initially documented in the late 1800s – are continuing in the Pilliga.

It is important to note the transitional and undesirable states the NRC has suggested are potential thresholds, and should be tested through an adaptive management process. Identifying potential thresholds is a practical approach to natural resource and conservation management when the exact tipping point in many natural ecosystems is not known (Central West Catchment Management Authority 2011). In practice, experienced land managers can often 'read the landscape' and tell when an ecosystem has shifted to an undesirable or alternate state, as it may begin to behave or function differently compared to its behaviour or function within the area of acceptable condition.

The NRC has provided these boundaries as an initial starting point for further testing and refinement in the NRC's recommended adaptive management framework (**Table 7, Section 5.1.2**,). As a first step, the NRC has set out an initial state and transition model containing and identifying particular ecosystem characteristics for areas of acceptable condition and management concern. This model is presented in **Section 9.2** as **Figure 19.**

[27] The authors also found bulloak (*Allocasuarina luehmannii*) and narrow-leaved Ironbark (*Eucalyptus crebra*) densities increasing too.

9.2.2 Ecologically and culturally sensitive areas and wildfire events

While State Conservation Areas are managed for conservation outcomes, some are likely to be more ecologically and culturally sensitive than others. If any active management interventions occur in State Conservation Areas, sensitive areas such as riparian areas close to waterways and Aboriginal cultural sites would need to be excluded, or potential risks would need to be closely managed.

The NRC has identified sensitive ecological and cultural attributes likely to occur in State Conservation Areas (**Table 15**), drawing on expert and agency advice and existing prescriptions (for example, from the *Brigalow and Nandewar Integrated Forestry Operations Approval* and the Private Native Forestry Code of Practice (NSW Government, 2010, 2007)). **Table 15** also lists suggested actions if active management occurs in these areas.

Since 2005, approximately 39,000 hectares of State Conservation Areas have been impacted by wildfire events. This has changed the overall vegetation structure (sometimes referred to as a stand conversion event), completely removing white cypress pine from many areas due to its sensitivity to fire. These fires provide land managers with opportunities to pre-emptively manage future white cypress pine densities in fire-affected areas (**Section 10.5**).

The NRC developed spatial layers to estimate in which areas sensitive ecological and cultural sites are present (see **Table 15** for summary of environmental and cultural attributes). Data was obtained from existing agency datasets such as the Atlas of NSW Wildlife, BioNet and Hydrolines.

The NRC found that in the State Conservation Areas:

- around 10 percent of the total area would be excluded from active management due to potential risks to waterways
- less than 1 percent of the total area would be excluded from active management for most ecological and cultural attributes
- around 6 percent of the total area would be excluded from active management due to impacts from wildfire events (mostly in Goonoo State Conservation Area).

Table 15: Summary of ecological, environmental and cultural attributes

Types of ecological, environmental and cultural areas	Example	Action	Estimated area (hectares and proportion of total State Conservation Area)
Aboriginal heritage	Aboriginal Object or Place, burial site, scarred or carved Tree Aboriginal Place	Exclude active management within specified area (i.e. buffers)	12 (less than one percent)
	Likely occurrence of heritage items	Identify and manage risks	
European heritage	Heritage items such as huts and sheds	Exclude active management within specified area (i.e. buffers)	
Waterways	Streams and wetlands	Exclude active management within specified area (i.e. buffers)	21,075 (10 percent)
Threatened fauna	Potentially over 40 species to consider such as barking owl nest sites and roosts for certain bats and birds	Exclude active management within specified area (i.e. buffers) Identify and manage risks	386 (less than one percent) (largely based on buffers around nest and roost sites)
Threatened flora	Potentially up to 17 species to consider such as *Homoranthus darwinioides* and *Boronia granitica*	Exclude active management within specified area (i.e. buffers) Identify and manage risks	17 (less than one percent)
Endangered Ecological Communities	White box, yellow box, blakely's red gum, box gum woodland and inland grey box woodland	Exclude active management within specified area (i.e. buffers) Identify and manage risks	3,953 (two percent)
Special landscape features	Caves, cliffs, heathlands and dams	Exclude active management within specified area (i.e. buffers)	89 (less than one percent)
Soils	Highly erodible soils	Identify and manage risks	No data

9.2.3 Applying the decision support framework to spatial data

The NRC has applied the framework and criteria described in **Table 14** to map and estimate the potential area of management concern for denser areas of white cypress pine in each State Conservation Area. Sensitive ecological, environmental and cultural attributes described in **Table 15** have been excluded in this assessment.

Table 16 shows the estimated areas for all the State Conservation Areas, while estimates for each State Conservation Area are presented in **Table 17**.

As an example, **Figure 20** shows the extent and distribution of areas of management concern in the Pilliga State Conservation Area. Mapping for each State Conservation Area can be found in their respective profiles within the *Draft report supporting profile and map book*.[28]

Based on the NRC's proposed criteria, the majority of land within the State Conservation Areas is likely to be in an acceptable condition with respect to dense white cypress pine (over 135,000 hectares or 70 percent of the total area). These are areas where the white cypress pine canopy coverage is relatively low, and/or where white cypress pine distribution is relatively 'patchy'.

Overall, approximately 57,000 hectares (or 30 percent of the total area of State Conservation Areas) have been identified as areas of management concern. Of this under the NRC's framework:

- 35,050 hectares (or 18 percent of the total area of State Conservation Areas) have been identified as occurring in a transitional state
- 22,092 hectares (or 12 percent of the total area of State Conservation Areas) have been identified as occurring in an undesirable state.

Areas of management concern within each State Conservation Area range from 1 hectare in Goodiman Creek State Conservation Area to 20,753 hectares in Pilliga State Conservation Area (or around 62 percent of its total area).

The limitations and confidence levels associated with the spatial data and analyses associated with each State Conservation Area is reported in **Attachment 3**.

[28] Booklet available online at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx

Table 16: Breakdown of areas of acceptable condition and areas of management concern

		Criteria	Area (hectares and proportion of total State Conservation Area)	
			Sub-total	Total
Areas with acceptable condition (State I)		Sensitive environmental and cultural areas and recent wildfires	**20,069** ▪ 15% of all areas of acceptable condition 10% of all SCAs	**135,940** **70% of all State Conservation Areas**
	A	All areas with little or no white cypress pine detected	**22,874** ▪ 17% of all areas of acceptable condition ▪ 12% of all SCAs	
	B	All white cypress pine canopy percentage classes 1- 4 (between 1 and 100 percent canopy coverage) with patch sizes less than 1 hectare	**12,677** ▪ 9% of all areas of acceptable condition ▪ 7% of all SCAs	
	C	White cypress pine canopy percentage class 1 (1 - 10 percent canopy coverage) with patch sizes greater than 1 hectare	**80,320** ▪ 59% of all areas of acceptable condition ▪ 41% of all SCAs	
Areas of management concern	Transitional state (State II)	**D** White cypress pine canopy percentage class 2 (11 - 20 percent canopy coverage) with patch sizes greater than 1 hectare and excluding sensitive environmental and cultural areas and recent wildfire events	**35,052** ▪ 61% of all areas of management concern ▪ 18% of all SCAs	**57,145** **30% of all State Conservation Areas**
	Undesirable state (State III)	**E** White cypress pine canopy percentage class 3 (21 - 30 percent canopy coverage) with patch sizes greater than 1 hectare and excluding sensitive environmental and cultural areas and recent wildfire events	**14,641** ▪ 25% of all areas of management concern ▪ 8% of all SCAs	
		F White cypress pine canopy percentage class 4 (greater than 31 percent canopy coverage) with patch sizes greater than 1 hectare and excluding sensitive environmental and cultural areas and recent wildfire events	**7,452** ▪ 14% of all areas of management concern ▪ 4% of all SCAs	

Table 17: Estimated areas of management concern for each State Conservation Area

State Conservation Area	Areas of acceptable condition (hectares)[29]	Area of management concern (**hectares/percentage**)			
		Class 2 (transition)	Class 3 (alternate)	Class 4 (alternate)	Total
Adelyne	**27 (18%)**	54 (36%)	48 (32%)	19 (13%)	**121 (82%)**
Beni	**1,584 (86%)**	218 (12%)	43 (2%)	4 (<1%)	**265 (14%)**
Biddon	**1,679 (50%)**	1,573 (47%)	101 (3%)	0 (0)	**1,673 (50%)**
Bingara	**1,674 (85%)**	211 (11%)	71 (4%)	23 (1%)	**305 (15%)**
Bobbiwaa	**1,515 (56%)**	721 (27%)	319 (12%)	133 (5%)	**1,173 (44%)**
Bullawa Creek	**55 (56%)**	41 (41%)	3 (<1%)	0 (0)	**44 (44%)**
Cobbora	**2,074 (92%)**	180 (8%)	6 (<1%)	1 (<1%)	**188 (8%)**
Durridgere	**5,141 (83%)**	724 (12%)	174 (3%)	133 (2%)	**1,030 (17%)**
Goodiman	**568 (>99%)**	1 (<1%)	0 (0)	0 (0)	**1 (<1%)**
Goonoo	**46,405 (85%)**	5,443 (10%)	1,926 (4%)	748 (1%)	**8,117 (15%)**
Goonoowigal	**689 (65%)**	312 (30%)	51 (5%)	3 (<1%)	**366 (35%)**
Gwydir River	**1,938 (74%)**	422 (16%)	159 (6%)	88 (3%)	**669 (26%)**
Killarney	**577 (31%)**	626 (34%)	444 (24%)	211 (11%)	**1,281 (69%)**
Leard	**736 (63%)**	300 (26%)	105 (9%)	35 (3%)	**440 (37%)**
Merriwindi	**719 (42%)**	642 (37%)	316 (18%)	53 (3%)	**1,011 (58%)**
Pilliga	**12,650 (38%)**	10,491 (31%)	6,144 (18%)	4,100 (12%)	**20,735 (62%)**
Pilliga East	**22,424 (91%)**	1,790 (7%)	353 (1%)	101 (<1%)	**2,244 (9%)**
Pilliga West	**24,184 (70%)**	7,211 (21%)	2,306 (7%)	714 (2%)	**10,231 (30%**
Tingha Plateau	**3,063 (90%)**	282 (8%)	60 (2%)	9 (<1%)	**352 (10%)**
Trinkey	**5,414 (53%)**	2,554 (25%)	1,423 (14%)	838 (8%)	**4,815 (47%)**
Warialda	**1,742 (60%)**	680 (23%)	340 (12%)	151 (5%)	**1,171 (40%)**
Wondoba	**755 (45%)**	573 (34%)	249 (15%)	87 (5%)	**908 (55%)**
Woodsreef	**328 (99%)**	3 (1%)	0 (0)	0 (0)	**3 (1%)**
Total	**135,940**	**35,052**	**14,641**	**7,452**	**57,145**

[29] Proportion is calculated against class 2, 3 and 4

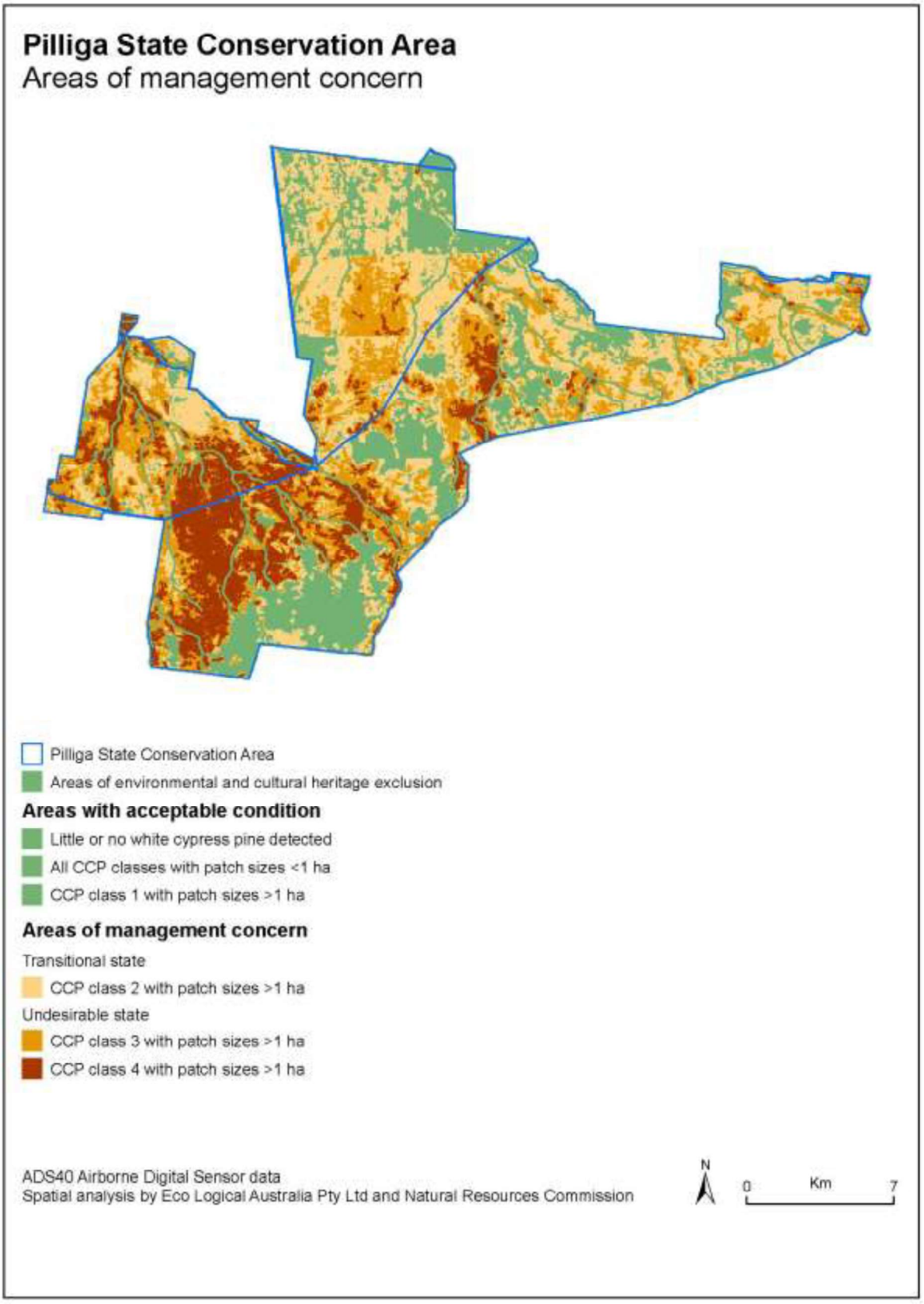


Figure 20: Areas of management concern in Pilliga State Conservation Area

9.3 Priority areas for active and adaptive management

Table 18 lists the seven State Conservation Areas where the area and proportion of areas of management concern is greatest. It also lists the number of patches over 500 hectares found in each relevant canopy class. Of note:

- Pilliga State Conservation Area has the highest amount of area across all three classes, including the number of patches over 500 hectares
- classes 3 and 4 contain only seven patches greater than 500 hectares (a total of 5, 725 hectares in total).

The NRC considers that the information in **Table 18** provides a practical starting point to help prioritise the development of plans of management for the State Conservation Areas. For example, land managers could focus on those State Conservation Areas that contain the largest patches found in the denser canopy classes – this would include Pilliga, Pilliga West, Goonoo and Trinkey State Conservation Areas.

It is important to note the image classification used for this analysis also includes bulloak trees in some areas of State Conservation Areas, a result verified by field surveys undertaken by the NRC. For example, some areas in Trinkey State Conservation Area are classed as areas of management concern for dense white cypress pine, but they also contain dense stands of bulloak. Land managers should investigate this issue further in priority State Conservation Areas, including strategies and interventions to reduce the environmental impacts of dense stands of bulloak.[30]

Relatively large areas of Goonoo and Pilliga East State Conservation Area have also been impacted by wildfire in the recent past. Land managers should consider the effects of fire when considering any active and adaptive management in these State Conservation Areas. In some cases, it may be more cost effective to develop post-fire active and adaptive management strategies to ensure that the re-establishment or creation of desired ecological values following a major fire event occurs (see **Section 10.5** for further discussion).

Table 18: State Conservation Areas where the areas of management concern is highest by area (number of patches over 500 hectares in that canopy class are shown in brackets)

Class 2	Class 3	Class 4
Pilliga (5)	Pilliga (3)	Pilliga (1)
Pilliga West (4)	Pilliga West (1)	Trinkey (0)
Goonoo (5)	Goonoo (2)	Goonoo (0)
Trinkey (3)	Trinkey (1)	Pilliga west (0)
Pilliga East (1)	Killarney (0)	Killarney (0)
Biddon (1)	Pilliga East (0)	Warialda (0)
Durridgere (0)	Warialda (0)	Bobbiwaa (0)

30 Whipp et al. (2012) suggest increasing dense stands of bulloak in the Pilliga may be an emerging issue, although regeneration of this species has received relatively little attention compared to white cypress pine.

10 Potential management options

Key points

KP 10.1 Interventions such as ecological thinning targeted grazing and prescribed fire can support progress towards environmental objectives. For example, ecological thinning can increase landscape heterogeneity, promote regeneration of trees such as eucalypts and shrubs, improve habitat and promote viable populations of native animals and plants.

KP 10.2 Optimising the location specific timing and intensity of these interventions is critical to ensure these interventions deliver a range of ecological benefits, including improving vegetation structure and floristic composition, and improving tree survival by reducing mortality in individual habitat trees.

Draft recommendations

1(a) The NRC recommends that interventions such as ecological thinning and targeted grazing be implemented in combination with existing management practices (prescribed fire and pest management) to maintain and improve environmental outcomes including encouraging regeneration of eucalypts; improving habitat for animals; improving groundcover and soil health; and reducing risk of intense wild fires. Any ecological thinning should be guided by the principles set out in **Table 24**.

This chapter addresses Element 4 of the adaptive management framework provided in **Table 7** – selection of management options. It describes how management options may be combined and sequenced depending on the management issues and objectives within a given area. This chapter also provides more information on proposed interventions including ecological thinning, targeted grazing and prescribed fire management.

10.1 Identifying potential management options

As shown in the state and transition model in **Section 9.2**, the NRC has identified four potential management intervention options:

- ecological thinning
- targeted grazing
- prescribed fire
- pest and weed control.

Of these proposed active management options, pest and weed management and prescribed fire management are already applied in State Conservation Areas to maintain and improve environmental outcomes, whereas ecological thinning and targeted grazing represent new intervention options. The NRC has recommended similar options in previous forest assessments. In addition, a range of other management options were also considered. **Box 3** provides more information on previous advice and additional options considered**.**

In **Table 19**, the NRC has linked the identified interventions to the each of the objectives proposed in **Table 13**. In some cases, the additional interventions identified could also support the achievement of other specific management directives within the current plans of management.

Table 19: Interventions linked to additional management objectives for State Conservation Areas

Additional objectives		Primary interventions	
		Additional	**Existing**
1	Maintain and enhance vegetation stand complexity including promoting areas of sclerophylous shrubs (for example, members of the *Myrtaceae*, *Proteaceae* and *Epacridaceae* families)	Ecological thinning	Prescribed fire
2	Maintain and enhance habitat for fauna including promoting numbers and growth of eucalypts where necessary	Ecological thinning	Weed and pest control Prescribed fire
3	Reduce stress on trees from resource competition, and enhance growth	Ecological thinning	-
4	Maintain and enhance groundcover, including diversity of native species	Ecological thinning Targeted grazing	Weed and pest control Prescribed fire

Table 20 provides a brief overview of the four active management options, including their potential ecological benefits and current application.

Table 20: Key active management interventions to maintain and enhance environmental outcomes

Intervention	Primary purpose	Ecological benefits*	Previous or current application
Ecological thinning	▪ Manipulate vegetation structure and composition	▪ Increase landscape heterogeneity ▪ Promote regeneration and growth of trees (especially eucalypts) and shrubs ▪ Improve habitat for fauna ▪ Promote viable populations of native fauna and flora species (especially of rare and threatened species)	▪ NSW Government is planning to undertake an ecological thinning trial in NSW river red gum forests (Natural Resources Commission, 2009; NSW Office of Environment and Heritage and Parks Victoria, 2012). ▪ Landholders can clear or thin white cypress pine on private or leasehold land to maintain or improve environmental outcomes under native vegetation regulations. ▪ The Department of Primary Industries' forest research team is also currently undertaking research on the effects of early thinning on biodiversity in river red gum state forests.

Intervention	Primary purpose	Ecological benefits*	Previous or current application
Targeted grazing	▪ Manipulate vegetation structure and composition ▪ Reduce fuel loads ▪ Reduce impact of weeds	▪ Promote diversity by controlling dominant species and habitat for fauna (likely limited circumstances, on a small-scale)	▪ Already applied in a limited number of NSW National Parks; see for example NSW Office of Environment and Heritage (2012d). ▪ NSW Office of Environment and Heritage is currently undertaking grazing trials on south-western cypress reserves and river red gum reserves to evaluate potential environmental, social and economic benefits and risks (NSW Office of Environment and Heritage, 2013d).
Prescribed fire	▪ Manipulate vegetation structure and composition ▪ Reduce fuel loads	▪ Increase landscape heterogeneity ▪ Promote regeneration and growth of trees (especially eucalypts) and shrubs ▪ Reduce risk of extensive and damaging fires	▪ These interventions are currently being carried out in the Brigalow and Nandewar State Conservation Areas, primarily to protect properties and assets; see for example NSW National Parks and Wildlife Service (2012c, 2013).
Pest and weed control	▪ Reduce impact of pests and weeds	▪ Promote viable populations of native fauna and flora species ▪ Improve groundcover ▪ Improve soil health	▪ Already applied in Brigalow and Nandewar State Conservation Areas, see for example (NSW Office of Environment and Heritage, 2012b).

* **Sources:** Ayers et al., 2001; Berney, 2013; Cohn et al., 2012; Date et al., 2002; Gibbons & Lindenmayer, 2002; Hobbs, 1999; Kerle, 2005; Lunt et al., 2006; Natural Resources Commission, 2010b; NSW Government, 2009; Ross et al., 2008

Although the outcomes of interventions such as thinning are well understood in a silvicultural context such as promoting tree growth (Knott, 1995), adaptive management will help address remaining uncertainties around the relative effectiveness of different interventions for delivering ecological outcomes. For instance, some studies indicate that the response of white cypress pine to thinning is not uniform across the landscape, and that in parts of western NSW thinning may not necessarily encourage increased growth and regeneration of eucalypts (Cohn et al., 2012).

Any of these activities can potentially influence biodiversity, soil health and riparian values. The NRC considers that the primary risks associated with the proposed interventions stem from these interventions being implemented at an inappropriate intensity, frequency and/or location, all of which could lead to diminished heterogeneity in the landscape. For example, inappropriate fire regimes could reduce 'patchiness' in the landscape and/or remove fire-sensitive white cypress pine trees from the landscape and reduce habitat extent or quality for rare and threatened species for many generations (Bowman & Latz, 1993). Plans of management should identify ecologically appropriate intensity, frequency and/or locations for each intervention option.

During the course of the review, stakeholders made suggestions as to how the National Parks and Wildlife Service could improve its current approach to fire management. Options for improving fire prescriptions are discussed in **Section 10.5**.

In this review, the NRC has assumed that current pest and weed management and prescribed fire activities will continue into the future under the adaptive management framework. As such the NRC did not set out to evaluate the National Parks and Wildlife Service's existing pest and weed management and prescribed fire regimes, and no additional guidance regarding pest and weed management is provided in this report.

Box 3: Previous advice and other options

The four potential active management interventions concur with those put forward in a previous forest assessment. In 2010, the NRC recommended that all white cypress pine forests and associated woodlands in south-western NSW should be actively and adaptively managed across all tenures, including through the use of ecological thinning, livestock grazing, prescribed fire management and (in State Forests) improvements to silviculture practices (Natural Resources Commission, 2010b).

In arriving at these proposed management interventions, the NRC investigated a range of other interventions that may be relevant within the Brigalow and Nandewar State Conservation Areas. For example, alternative interventions proposed in submissions included the reintroduction of top predators (such as dingos), the use of quandongs in vegetation management and traditional Aboriginal fire management.

There is scientific literature on the impact of dingo exclusion or reintroduction on foxes and consequently on native animal species, but very little that discusses the impacts of dingo management on native vegetation (see Moseby et al. 2012). With respect to traditional Aboriginal fire management, some Aboriginal stakeholders have indicated the cultural knowledge of Aboriginal burning practice has been lost in the Brigalow and Nandewar region (NRC consultation with Aboriginal stakeholders, November 2013).

10.2 Combination and sequencing of management options

Managers are likely to be faced with different management scenarios across the State Conservation Areas. In each scenario, decisions around the most appropriate management strategy will be influenced by a unique combination of factors, including the:

- risks and implications of change in a system
- identified management objectives
- extent and configuration of dense white cypress pine, both in the immediate area and within the broader State Conservation Area
- available management resources.

Managers should be given the flexibility to choose an appropriate management strategy based on the unique context of a particular location and the comparative cost effectiveness of available options. For example, depending on the area, managers may choose to address class 2 transitional areas in different ways, including:

- through on ground interventions such as ecological thinning – for instance, if these areas are particularly widespread, are adjacent to class 3 and 4 management priority areas, or if management of these areas is more cost effective than intervention in denser stands

- by applying a 'watching brief' – for example, periodically monitoring the area of concern using remote sensing to identify further increases in white cypress pine density and extent over time.

In addition, the proposed active management options of ecological thinning, targeted grazing and prescribed fire may need to be combined or sequenced to:

- effectively achieve the desired management outcomes
- address natural ecosystem responses
- ensure any ecological benefits gained by investing in active management are maintained in the long-term.

When developing a plan of management, planners need to consider how these potential interventions can work together to deliver optimal ecological outcomes (Date et al., 2002).

For example, ecological thinning could be applied to open up dense stands of white cypress pine and to encourage the germination of diverse species of trees, shrubs and grasses. However, in some cases, this could also encourage the dense regrowth of white cypress pine due to the existing seed bank in the soil. Further active management, such as prescribed burning or grazing, may be required to maintain the desired state.

Table 21 describes some of the potential combinations and sequences for active management options, including potential ecological risks.

Table 21: Potential combinations and sequences for applying active management options

Proposed additional objective	First intervention	Second intervention	Potential ecological risks
Maintain and enhance vegetation stand complexity including areas of sclerophyllous shrubs	*Prescribed fire*	*Prescribed fire*	▪ Complete removal of white cypress pine (after first and second intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Damage to mature white cypress pine trees (first and second intervention)
	Ecological thinning	*Prescribed fire*	▪ Increase fuel loads (after first intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Complete removal of white cypress pine after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature white cypress pine trees (second intervention)
	Ecological thinning	*Selective grazing*	▪ Increase fuel loads (after first intervention) ▪ Decrease groundcover (after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention)
	(Wildfire)	*Prescribed fire*	▪ Complete removal of white cypress pine (after first and second intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Damage to mature white cypress pine trees (second intervention)
Maintain and enhance habitat for fauna including promoting numbers of eucalypts where necessary	*Ecological thinning*	*Prescribed fire*	▪ Increase fuel loads (after first intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Complete removal of white cypress pine after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature white cypress pine trees (second intervention)

Proposed additional objective	First intervention	Second intervention	Potential ecological risks
	Prescribed fire	*Prescribed fire*	▪ Complete removal of white cypress pine (after first and second intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Damage to mature white cypress pine trees (first and second intervention)
Reduce stress on trees from resource competition, and enhance growth	*Ecological thinning*	*Prescribed fire*	▪ Increase fuel loads (after first intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Complete removal of white cypress pine after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature white cypress pine trees (second intervention)
Maintain & enhance groundcover, including diversity	*Ecological thinning*	*Prescribed fire (or targeted grazing)*	▪ Increase fuel loads (after first intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Complete removal of white cypress pine after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature white cypress pine trees (second intervention)

10.3 Ecological thinning

The purpose of ecological thinning is to selectively remove trees or dense stands of vegetation to achieve specified ecological outcomes (Cunningham et al., 2009).

The NRC suggests ecological thinning could be applied in two ways:

- thinning vegetation regrowth to a uniform, predetermined density
- thinning trees to open up dense stands (in some cases, around specified features such as habitat trees or potential habitat trees, including large canopied white cypress pine trees).

In either case, thinning residues may be left in the forests, or removed. **Figure 21** shows an example of ecological thinning with residues left on the ground.

In all cases, some dense stands of white cypress pine should be retained in the landscape to maintain a mosaic pattern of vegetation (Ayers et al., 2001).

In the State Conservation Areas, proposed objectives that may be achieved through thinning are identified in **Table 20**, and include maintaining and enhancing:

- vegetation stand complexity including promoting areas of sclerophyllous shrubs
- habitat for fauna, including improving number and structure of eucalypts where necessary
- reducing stress on trees from resource competition, and enhance growth.

10.3.1 Environmental benefits

In general, ecological thinning can help to reduce competition between vegetation for limited resources such as water, light and nutrients, and promote landscape heterogeneity (Ross et al., 2008). **Table 22** outlines the potential benefits of ecological thinning.

Table 22: Benefits of with ecological thinning

Benefit	Discussion
Improve vegetation structure and floristic composition	▪ Ecological thinning can improve vegetation structure and floristic composition by increasing landscape 'patchiness' in areas that are otherwise relatively homogenous (Cameron, 2003; Hobbs, 1999). ▪ Ecological thinning provides opportunities to incorporate vegetation mosaics or patchiness into the landscape. Patchiness improves ecological processes, and provides a matrix of dense and more open stands of vegetation which is important for native fauna (Ayers et al., 2001; Hobbs, 1999; Noss, 1990).
Increase eucalypts in white cypress pine-dominated landscapes	▪ Ecological thinning can increase eucalypts in the white cypress pine-dominated landscape by promoting tree growth in existing eucalypts, and increasing recruitment over time (Maher, 1995). ▪ **Section 6.4.1** explained the ecological value of eucalypt species within the landscape. ▪ Ecological thinning of dense white cypress pine regeneration will promote recruitment of young eucalypts within the gaps created. Ecological thinning of white cypress pine trees competing with eucalypts with high habitat potential will reduce stress and promote growth in existing trees (see **Figure 21**).
Promote tree growth and habitat quality	▪ Ecological thinning can promote the formation of hollows (Briggs & Tooth, 1994; Horner et al., 2010), which is related to the form and size of a tree, in particular its lateral branch abundance and crown size (Horner et al., 2010; Rayner et al., 2014). This is a long-term outcome, as tree hollows can take up to 100 years to form (Gibbons & Lindenmayer, 2002). ▪ Bimble box (*Eucalyptus populnea*), yellow box (*Eucalyptus melliodora*), river red gum (*Eucalyptus camaldulensis*) and grey box (*Eucalyptus microcarpa*) are typical hollow-forming eucalypts (Rayner et al., 2014). Of these, grey box is more likely to form hollows compared to other species with stems of a similar size (ibid.). ▪ Ecological thinning of white cypress pine trees will promote growth in existing trees and high habitat potential, including both white cypress pine and eucalypts (see **Figure 21**).

Benefit	Discussion
Increase viability of threatened species	▪ Improving, or increasing, particular habitat types through ecological thinning in white cypress pine woodland is likely to support or increase the viability of threatened species. ▪ Date et al. (2000) indicates that within white cypress pine woodlands: - 26 threatened species rely on mature eucalypts and associated hollows (three reptiles, 10 birds, 13 mammals) - 22 threatened species rely on grassy woodlands and grasslands (two reptiles, 9 birds, 11 mammals) - six species rely on mixed understorey woodland (one bird, five mammals) (Date et al., 2000)
Increase coarse woody debris by thinning residues	▪ Ecological thinning can increase the amount of coarse woody debris on the ground through the retention of a proportion of thinning residues (Horner et al., 2009; Killey et al., 2010). ▪ Along with tree hollows and food resources, coarse woody debris is one of the most important resources for native fauna in forest ecosystems (Lindenmayer et al., 2006; Kirby, 1992). ▪ For example, fauna species such as the yellow-footed antechinus (*Antechinus flavipes*) and brown treecreeper (*Climacteris picumnus*), which are widespread in central west white cypress pine forests, are likely to benefit from enhanced coarse woody debris level in State Conservation Areas (MacNally & Horrocks, 2008). Reptiles such as geckos are also likely to benefit from increased debris in the Pilliga region (Duckett & Stow, 2011).
Improve tree survival by reducing mortality in individual trees	▪ At a patch scale, individual large trees (including 'old greys' white cypress pine – see **Figure 22**) are more likely to provide important resources for fauna compared to smaller trees (Gibbons & Lindenmayer, 2002). ▪ Thinning can promote greater resilience in individual trees by allowing greater access to resources such as water and nutrients. ▪ In general, large canopy trees tend to suffer stress and mortality in the presence of dense white cypress pine regeneration, particularly during water scarcity, and more white cypress pine regeneration is likely to replace dying white cypress and eucalyptus trees (Cohn et al., 2012).
Enhance soil health	▪ Ecological thinning can enhance soil health (McHenry et al., 2006). ▪ It can also promote increased groundcover and biomass (CWCMA and WCMA, 2010), which can reduce erosion (such as sheet and rill erosion) and improve the overall health of soil (for example, carbon content and structure) and soil biodiversity (NSW Office of Environment and Heritage, 2006).

Figure 21: Example of thinning around a potential habitat tree

Figure 22: Example of a mature white cypress pine with spreading crown (sometimes referred to as 'old greys')

10.3.2 Risks to environmental values

There are risks associated with ecological thinning, but they can be managed with appropriate adaptive management frameworks, outcomes based prescriptions and standards, and assurance mechanisms such as periodic formal evaluations and internal and independent audits.

Table 23 outlines the potential risks associated with ecological thinning.

Table 23: Risks associated with ecological thinning

Risk	Discussion
Reducing coarse woody debris where thinning residues are removed	▪ In general, management practices that deplete pre-existing and any new coarse woody debris should be avoided, where this is consistent with other management goals such as fire protection (Natural Resources Commission, 2010b). ▪ This risk can be managed by defining specific threshold levels for retaining coarse woody debris in given locations. To date, there have been no formal studies examining coarse woody debris use in white cypress pine forests. As such, there are currently no specific threshold levels for coarse woody debris in white cypress pine reserves. ▪ In some areas, coarse woody debris levels may need to be increased where little or none exist (for example, in existing dense stands).
Reducing nutrients and litter where thinning residues are removed	▪ This risk can be managed by defining specific threshold levels for retaining coarse woody debris, in particular leaf crowns in given locations. ▪ Dense stands can accumulate large amounts of leaf litter, in the order of over 2,000 kilograms per hectare annually (Hart, 1995). This can increase water-holding capacity and help promote germination and growth of groundcover species.
Increasing fire fuel loads where thinning residues are left	▪ This risk can be managed by defining specific threshold levels for retaining coarse woody debris in given locations. There are currently no specific thresholds levels for coarse woody debris in white cypress pine reserves. ▪ National Parks and Wildlife Service fire management strategies establish fire frequency thresholds based on biodiversity thresholds and specific areas for prescribed burns to reduce fuel loads (NSW National Parks and Wildlife Service, 2013).
Impacting fauna that relies on white cypress pine	▪ This risk can be managed by appropriate prescriptions such as retaining large white cypress pine trees. ▪ The red-capped robin (*Petroica goodenovii*) and yellow thornbill (*Acanthiza nana*) are commonly found in white cypress pine forests, although they are also found in eucalypt woodlands (Antos & Bennett, 2005). ▪ Koalas (*Phascolarctos cinereus*) rely on eucalypts as a food resource but also use larger white cypress pine trees for occasional daytime shelter (Kavanagh & Barrott, 2001). Koalas appear to be under stress caused by high summer temperatures, infections from wounds inflicted by introduced cactus species and wildfire (Kavanagh et al., 2007). Minimising disturbance to forests along creeks and other drainage lines may benefit koalas. These areas are more likely to serve as important drought refuges for this species because they provide vigorous growing eucalyptus foliage and higher moisture content in the foliage (Kavanagh & Barrott, 2001).

Risk	Discussion
Impacting and/or disturbing soil crusts, vegetation, soil and fauna with machinery	▪ This risk can be managed by appropriate prescriptions and machinery design. ▪ The *Brigalow and Nandewar Integrated Forestry Operations Approval* sets out a range of prescriptions for using and operating machinery in State Forests, such as the location and timing of operations (NSW Government, 2010).
Increasing weeds, feral predators and native species invasion	▪ This risk can be managed by appropriate pest and weed management strategies. ▪ Key pest and weeds found in State Conservation Areas include the African boxthorn (*Lycium ferocissimum*), tiger pear (*Opuntia aurantiaca*), mother of millions (*Bryophyllum delagoense*), prickly pear (*Puntia* spp.), feral pig (*Sus scrofa*), fox (*Vulpes vulpes*) and European rabbit (*Oryctolagus cuniculus*) (NSW Office of Environment and Heritage, 2012b). ▪ Ecological thinning increases light levels at the soil surface, potentially encouraging recruitment, distribution and abundance of invasive weeds (Berney, 2013). ▪ Feral pest animals could also increase in number by increasing foraging opportunities through increased groundcover and biomass (Berney, 2013). Open woodlands could also encourage dispersal of feral pest animals. Alternatively, dense stands of vegetation also offer protection and resting places for pest animals. ▪ Opening woodlands may encourage invasion of dominating native noisy miners (*Manorina melanocephala*) (Maron & Kennedy, 2007). This species is aggressive, and can exclude small birds from woodland forests. Maintaining a proportion of dense vegetation stands may minimise the risk of noisy miner invasion (Eyre et al., 2009; Hastings & Beattie, 2006).

10.3.3 Current use

Ecological thinning in any form has not been applied in the Brigalow and Nandewar State Conservation Areas since they were proclaimed as part of the reserve system. This is despite Clause 11.13 of the *Brigalow and Nandewar Community Conservation Area Agreement 2009* specifically allowing for 'non-commercial thinning' of dense white cypress pine regrowth to enhance habitat values and ecosystem function.[31]

The NSW Government has approved ecological thinning on a trial basis in river red gum reserves to determine the effectiveness of management options in addressing high stem density and canopy dieback in stands of river red gum forest (NSW Office of Environment and Heritage and Parks Victoria, 2012). As part of this trial, the NSW Government authorised the non-commercial collection of timber for a fee. The trial is currently under assessment and approval as a controlled action under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Box 4: Silvicultural treatments on State Forests (Zone 4) and private land

As part of the State Forests estate, State Conservation Areas were previously managed using silviculture treatments[32] and forest management zoning to promote white cypress pine timber production and maintain ecosystem function (State Forests of NSW, 2000). The Forestry Corporation of NSW applies a silvicultural system and management prescriptions for white cypress pine that have evolved as a result of experience and research since formal forest management began in the region in the early 1900s (State Forests of NSW, 2000).

In State Forests within the Brigalow and Nandewar region, the Forestry Corporation of NSW operates under the Brigalow and Nandewar Integrated Forestry Operations Approval, which commenced in 2010. This is an agreement between the Minister for the Environment and the Minister for Primary Industries, and describes the forestry operations and area to which a Forest Agreement applies. It also sets out the terms of relevant licences under the NSW Protection of the Environment Operations Act 1997, the Threatened Species Conservation Act 1995 and the Fisheries Management Act 1994.

Similar silviculture treatments are applied to white cypress pine forestry on private land under the *Native Vegetation Act 2003* (NSW), which requires environmental outcomes to be maintained or improved.

31 Non-commercial thinning is a silviculture practice used in white cypress pine forestry to promote timber growth for production values. The NRC has previously recommended non-commercial thinning should be implemented on public lands as good natural resource management practice (Natural Resources Commission, 2010b).

32 Three phases of silviculture treatments – non-commercial thinning, commercial thinning and harvesting - are applied rotationally to white cypress pine trees over a nominal 100 year period to optimise timber production and maintain ecosystem function (Natural Resources Commission, 2010b).

10.3.4 Where and how these interventions could be applied

The NRC considers that the use of ecological thinning should primarily be determined on the basis of the:

- specific management objective trying to be achieved
- structure of the surrounding vegetation, not just the size and age of trees alone.

Section 9.2.3 described the spatial extent and distribution of potential areas of management concern based on areas of denser white cypress pine. These could be considered as areas for ecological thinning, including Pilliga, Pilliga West, Goonoo and Trinkey State Conservation Areas as priority areas (**Section 9.3**).

Ecological thinning should vary in density throughout the area being managed as tree spacing is not uniform in nature, and should also be staged through space and time to ensure that there are stands of differing age and structure throughout the landscape. Managers should also consider the landscape context the activity will occur in, including the extent and condition of surrounding vegetation at different scales. For example, dense stands of white cypress pine may be relatively rare in the surrounding landscape (and other tenures) and may need to be retained in State Conservation Areas to support ecological function.

Rather than a set of specific rules or prescriptions, the NRC – in consultation with agency stakeholders and other experts – has developed a working set of principles to support managers in applying any ecological thinning that may occur in these potential areas of management concern (or any other areas). These principles are set out in **Table 24**, and promote the maintenance and improvement of structural and floristic diversity across the State Conservation Areas.

Table 24: Principles for ecological thinning in State Conservation Areas

Principles for ecological thinning
Any ecological thinning should:
1. Be applied to areas where management objectives can be reasonably predicted and expected.
2. Vary in density throughout the area being managed as tree spacing is not uniform in nature over a large area.
3. Be determined on the basis of the structure of the surrounding vegetation rather than the age of trees alone.
4. Promote a variety of tree ages, size and species both within a site and in the landscape.
5. Promote areas of sclerophyllous shrubs without losing all existing shrub habitat in the process.
6. Maintain or enhance levels of coarse woody debris where necessary and practical, and consistent with other objectives such as fire management objectives.
7. Consider the potential time lags between the intervention and the desired management objective.
8. Consider the landscape context the activity will occur in, including the extent and condition of surrounding vegetation at different scales and on different tenures.
9. Only be implemented if adequate and robust monitoring and evaluation regimes can be established and maintained.

Managers should have the flexibility to employ a range of thinning regimes and treatment levels over space and time, depending on the ecological requirements of a particular area.

However, in practice managers may also choose to identify a smaller suite of discrete thinning and/or gapping levels in their design to assist their adaptive management process by simplifying monitoring and allowing for controlled comparison of treatments. For example, the river red gum thinning trials have drawn off existing silviculture treatments and nominated three thinning treatment levels - heavy thinning, moderate thinning and control areas.

10.4 Targeted grazing

The purpose of this active management option is to selectively apply targeted livestock grazing to achieve specified ecological outcomes.

10.4.1 Discussion of potential environmental benefits and risks

In the past, heavy livestock grazing has caused substantial damage to white cypress pine forests and associated woodlands, and more broadly across Australian ecosystems (Lunt et al., 2007). Total grazing pressure from other pest species (such as rabbits) and native herbivores, especially kangaroos can also cause ecological degradation (Sluiter et al., 1997). It is likely that heavy grazing has impacted on most woodland birds in regrowth and mature woodland within the Brigalow region, particularly by contributing to an increased number of noisy miners (*Manorina melanocephala*) (Bowen et al., 2009).

Despite the historical impacts of livestock grazing, in different circumstances current livestock grazing regimes may have positive or neutral impacts on environmental values (Lunt et al., 2007; Martin & Possingham, 2005). Studies and strategies have suggested:

- some bird species such as the brown treecreeper (*Climacteris picumnus*), crested bellbird (*Oreoica gutturalis*), hooded robin (*Melanodryas cucullata*) and jacky winter (*Microeca fascinans*) are more common on sites that are lightly grazed rather than heavily grazed sites in south-west Queensland and North Western NSW (James, 2003)
- brown treecreepers, hooded robins and speckled warblers (*Chthonicola sagittata*) avoid sites with weeds and exotic grasses (Maron & Lill, 2005)
- the brown treecreepers went extinct in two sites that became national parks, possibly because light grazing by livestock ceased and they became overgrown (Ford et al., 2009)
- provide a disturbance regime to maintain and enhance vegetation structure and composition (NSW Office of Environment and Heritage, 2012a)
- reduce weeds and fuel loads (Wilson et al., 1997).

However, any positive ecological impacts are likely to be restricted to highly productive soils where livestock grazing may enhance small-scale vegetation diversity by reducing competition from dominant grasses (Natural Resources Commission, 2010b). This may benefit some woodland birds (Martin & Possingham, 2005; Martin et al., 2005). Grazing will not promote vegetation structure and diversity if the target species is unpalatable to livestock (and therefore rarely eaten) or unavailable to livestock (for example, tall trees and shrubs) (Lunt et al., 2007).

In comparison to ecological thinning and prescribed fire, livestock grazing is therefore likely to have more limited application as an active management intervention.

A lack of comprehensive monitoring of – and data on – grazing impacts in white cypress pine forests has meant it is not possible to assess how livestock grazing affects conservation values or fire risk.

A grazing trial underway in south-western cypress reserves is broadly aimed at developing evidence to inform future management decisions about the ecological impact and benefits of stock grazing (NSW Office of Environment and Heritage, 2013d). The trial is measuring a range of ecological parameters such as soil health, litter biomass, organic soil matter, native and exotic plant cover, recruitment of overstorey and mid-storey plants and abundance of reptiles, invertebrates and birds (NSW Office of Environment and Heritage, 2013d).

There is an opportunity to transfer learnings from this trial to the Brigalow and Nandewar State Conservation Areas, although there is also the need to recognise differences, such as rainfall, temperature and soil profiles.

10.4.2 Current use

Livestock grazing has not been applied in the Brigalow and Nandewar State Conservation Areas since they were proclaimed as part of the reserve system. However, livestock grazing is carried out:

- in many white cypress pine State Forests to reduce fire fuel loads – there are currently 33 grazing permits in State Forests within the Brigalow and Nandewar region (Community Conservation Area Zone 4)[33]
- in NSW reserves, for example, to maintain and enhance habitat for the plains wanderer (*Pedionomus torquatus*) bird (NSW Office of Environment and Heritage, 2012a)
- across a range of south-western cypress forests and river red gum reserves to evaluate the potential environmental, social and economic benefits and impacts (NSW Office of Environment and Heritage, 2013d).

10.4.3 Where and how these interventions could be applied

Targeted grazing should only be applied to areas where management objectives can be reasonably predicted and expected, and rigorously monitored and assessed in a formalised monitoring system (Natural Resources Commission, 2010b).

The NRC believes livestock grazing could be selectively applied on a small-scale as a cost-effective:

- secondary activity following ecological thinning, to maintain vegetation structure and diversity
- activity to reduce fire fuel loads and weed densities.

Previous studies suggest positive outcomes may be achieved where livestock grazing can:

- prevent invasion by undesirable weeds in an area
- maintain small-scale diversity by controlling dominant species in an area (Lunt et al., 2007)

Lunt et al. (2007) concluded there are some circumstances where there is enough uncertainty as to whether positive or negative outcomes could be expected. In these cases, further study or trials may be warranted.

[33] Grazing permit data supplied by Forestry Corporation of NSW, December 2013.

As such, grazing within the Brigalow and Nandewar State Conservation Areas could be carried out on specific sites as an extension of the current south-western cypress and river red gum grazing trials. This would enable greater knowledge generation and sharing of information about the outcomes, risks and benefits of grazing in white cypress pine forests as an active management tool for ecological outcomes.

Ideally, differential areas of fire risk could be identified within State Conservation Areas to allow more strategic grazing for fire control within a spatial framework rather than relying on forest-wide grazing. However, this would require internal fencing and would potentially inhibit animal movements.

The NRC notes there are instances where current plans of management explicitly prevent grazing, for example, in the plan of management for Leard State Conservation Area. Here grazing is not permitted as it (along with fire and firewood collection) has been identified as a threat to the endangered white box-yellow box-blakely's red gum woodland and Brigalow communities (NSW National Parks and Wildlife Service, 2012e).

10.4.4 Lessons from previous grazing strategies

Previous grazing strategies in white cypress pine forests suggest using only cattle, which are more effective than sheep at reducing fire hazards. Cattle graze more evenly and reduce the height of grass tussocks. They also cause less damage to regenerating trees and herbaceous plants (Wilson et al., 1997).

Sheep eat white cypress pine seedlings (Lacey, 1972), and are used to control white cypress pine regrowth on private land. However, there is a risk that diversity may decline if grazing animals preferentially select other species rather than the target species (Lunt et al., 2007).

Other prescriptions for livestock grazing in white cypress pine forests include that:

- herbaceous biomass should not be grazed below 5 centimetres or 500 kilograms per hectare over the warmer months of December and April to reduce the danger of overgrazing
- some areas should be closed to grazing over summer on a rotational basis, once every three years on average, to enhance biodiversity values
- sufficient stock should be grazed to reduce biomass to 1.5 tonnes per hectare by the end of November as the fire danger is significantly reduced at these levels (Wilson et al., 1997).

10.5 Improved prescribed fire

Fire is a natural feature of many environments and is essential for the survival of some plant communities (Prober et al., 2008). Appropriate fire management can:

- maintain and enhance vegetation structure and floristic composition, for example by thinning dense stands of vegetation (Prober et al., 2008)
- maintain and enhance tree, groundcover and shrub regeneration (Wilson et al., 1997)
- reduce fuel loads, which can affect conservation and social values (NSW National Parks and Wildlife Service, 2013).

Prescribed fire is already used within the State Conservation Areas. There are 22 fire management strategies for Brigalow and Nandewar State Conservation Areas (**Attachment 2**). They broadly aim to:

- protect life, property and community assets from the adverse impacts of fire
- develop and implement cooperative and coordinated fire management arrangements with other fire authorities, reserve neighbours and the community
- manage fire regimes within reserves to maintain and enhance biodiversity, protect Aboriginal sites known to exist within NSW and preserve historic places and culturally significant features
- assist other fire management agencies, land management authorities and landholders in developing fire management practices to conserve and protect biodiversity, cultural heritage and life and property across the landscape (NSW Office of Environment and Heritage, 2008).

The National Parks and Wildlife Service is moving towards explicit one-page spatial strategies that set out (among other things):

- critical wildfire seasons and effective prescribed burns
- operation guidelines for wildfire events and prescribed burns
- fire thresholds for potential impacts on biodiversity values
- recommended areas for prescribed burns, based on biodiversity thresholds.

The NRC supports spatial expression of strategic plans, especially where it can capture and communicate important thresholds in the landscape and priorities for action (Natural Resources Commission, 2010a).

The threat of wildfire remains a key concern for local communities, and is a key focus for the National Parks and Wildlife Service management.

During this review, the NRC found that:

- regional National Parks and Wildlife Service management and staff members coordinate fire management arrangements with other fire authorities, such as the Rural Fire Service
- prescribed burns have been applied to 16,000 hectares of State Conservation Area since 2005, with more than 80 percent of the events occurring in the cooler months of autumn and only 8 percent occurring in the months of spring since 2005 (**Figure 23**)[34]
- wildfires have burnt up to 40,000 hectares (or 20 percent) of the State Conservation Areas since 2005 (**Figure 23**) – these fires can remove entire stands of vegetation, including both fire-tolerant (eucalypt) and fire-intolerant (white cypress pine) species and important habitat values such as hollows
- there is a gap between strategic intent and actual practice. For example, the National Parks and Wildlife Service intends to deliver a patch-work of low-intensity burns though the State Conservation Areas; however, most fire management strategies specify that a high intensity fire may be permitted after a fire-free period of 25 to 50 years – that is, after 25 years (and up to 50 years), a high-intensity prescribed burn can be applied.

34 Based on spatial database supplied by Office of Environment and Heritage.

The NRC suggests the National Parks and Wildlife Service:

- update its fire strategies to better align strategic intent with on-ground practices to provide clear directions for current and future staff
- develop post-fire active and adaptive management strategies to ensure the re-establishment or creation of desired ecological values following a major fire event
- update strategies to identify areas in which critical habitat features (such as hollow trees, younger trees likely to mature into hollow trees, or intact existing grassy vegetation communities) could be prioritised for protection and active management
- consider how to effectively use prescribed fire in a broader active and adaptive management strategy, for example, how it could be combined or sequenced with other interventions to best meet desired outcomes (refer to **Section 10.2**).

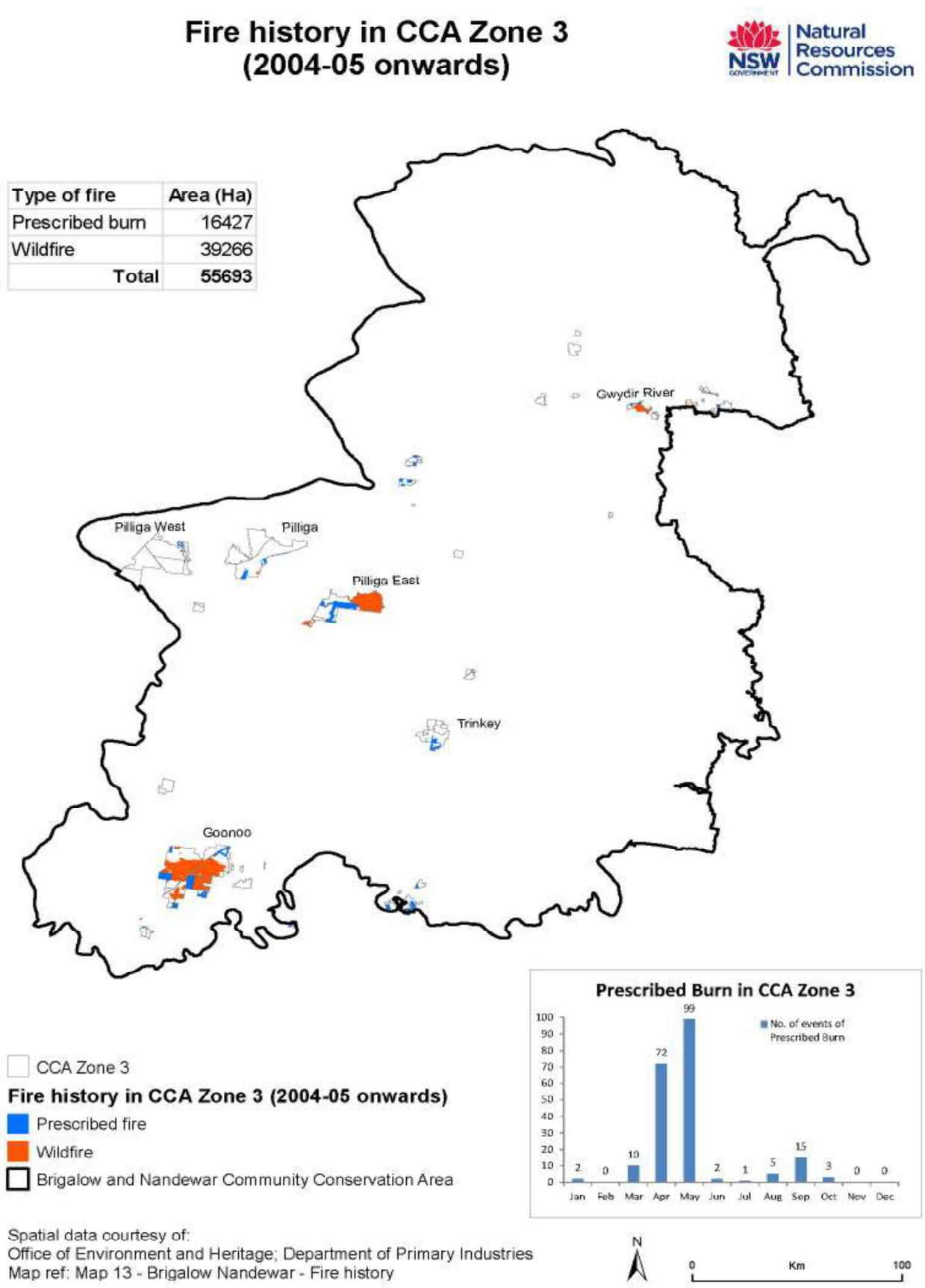


Figure 23: Fire history in the Brigalow and Nandewar State Conservation Areas since 2004-2005

11 Costs and potential revenue

Key points

KP 11.1 For all management interventions there will be administrative and operational costs incurred by the NSW Government. The overall cost will depend on the location and extent of land being actively managed, and on the chosen intervention regime.

KP 11.2 The NRC has modelled indicative costs for an example ecological thinning program that addresses areas of concern in four priority State Conservation Areas, namely Goonoo, Pilliga, Pilliga West and Trinkey. Total program are estimated to vary between $320 per hectare for moderate levels of thinning and $575 per hectare for heavy levels of thinning.

KP 11.3 Indicative program costs could be reduced by up to 15 percent if periodic performance audits are adopted instead of direct supervision by reserve managers. This would reduce the program costs to $300 per hectare for moderate levels of thinning, and $560 per hectare for heavy levels of thinning. In practice, it is likely that the thinning program would focus on small, targeted areas for intervention, thus further reducing the extent and cost of any ecological thinning program.

KP 11.4 Cost recovery most likely relates to the use of larger stems being thinned. Revenue generated largely through the sale of sawlogs and some landscaping products could offset program costs by 30 to 40 percent, depending on the level of thinning treatment. This could reduce program costs to between $215 per hectare for moderate levels of thinning, and $330 per hectare for heavy levels of thinning.

KP 11.5 Under a 'goods for services' scheme, program costs could be further reduced to $40-$330 per hectare, depending on the costs incurred by parties engaged to undertake services and the mix of production and non-production material that can be removed and sold.

KP 11.6 Indicative costs of using prescribed fire under an adaptive management program are estimated to start at $50 per hectare. Targeted grazing is only likely to be used in limited circumstances, with the primary costs being the installation and maintenance of fencing and water points.

KP 11.7 Commercial opportunities and cost recovery avenues regards the use of ecological thinning residues for bioenergy are currently limited, and focus primarily on electricity generation. However, there is potential for future growth and opportunities within this sector.

Draft recommendation

4(a) The NRC recommends where active and adaptive management is undertaken to enhance environmental outcomes, the NSW Government seek secondary commercial benefits, as appropriate to off-set costs, improve long-term sustainability of the program and deliver social and economic benefits to local industries and communities.

4(b) The NRC recommends that the NSW Government explore the use of a 'goods for services' scheme as an effective means of cost recovery when implementing an ecological thinning program.

This chapter examines the potential cost of undertaking active and adaptive management in the State Conservation Areas. It also explores potential avenues for recovering costs by commercially processing, where appropriate, the ecological thinning residues into products such as sawlogs and landscaping products.

The NRC used the following variables to model and estimate the potential costs and cost recovery:

- moderate and heavy thinning regimes
- density classes 1, 2 and 3 (and relevant area) in the four priority State Conservation Areas (**Section 9.3**)
- a seven year period.

Based on the above model, the NRC has developed three cost and cost recovery options to consider:

1 No cost recovery

2 Partial cost recovery

3 Partial to full cost recovery through a 'goods for services scheme'.

Table 25 summarises the NRC's modelled estimated costs and cost recovery options.

It is important to note that the estimates are a modelled program with fixed variables. In practice, it is likely that the Adaptive Management Plan and supporting plans of management will focus on even more targeted priority areas for thinning, thus reducing the extent and cost of the thinning program. Thinning intensity is also likely to be determined on an area-by-area basis, informed by field reviews and taking into account individual forest attributes and objectives.

Table 25: Summary of estimated costs for ecological thinning program

Option		Annual gross program costs		Annual gross program costs per hectare		Comment
		Lower estimate (moderate thinning)	Upper estimate (heavy thinning)	Lower estimate (moderate thinning)	Upper estimate (heavy thinning)	
1	No cost recovery	$1.9m	$3.5m	$300	$560	▪ Modelled on treating 6,721 hectares per year in priority State Conservation Areas. ▪ Program management and direct costs incurred by reserve managers. ▪ No cost recovery through commercially utilising ecological thinning residues. ▪ Based on periodic performance audit model for accountability.
2	Partial cost recovery	$1.3m	$2m	$215	$330	▪ Higher ratio of smaller to larger trees thinned (lower commercial value). ▪ Full program management cost incurred by land managers. ▪ Partial direct costs recovered through revenue generated from sale of thinning residues. ▪ Based on periodic performance audit model for accountability. ▪ Cost recovery for direct costs could increase if a higher number of larger trees are thinned and recovered as sawlogs.
3	Goods for services scheme	$0.5m-$1.3m		$40-$330		▪ Full program management cost incurred by reserve managers. ▪ Partial to full direct costs and benefits incurred and accrued by party undertaking thinning.

11.1 Cost of active and adaptive management

For all management interventions there will be administrative and operational costs incurred by the NSW Government. The overall cost will depend on the location and extent of land being actively and adaptively managed, and on the chosen intervention regime, all of which should be determined by the objectives within State Conservation Area plans of management. In the absence of these plans and objectives, the following sections provide a high-level indication of potential costs that may be associated with each intervention option.

11.1.1 Ecological thinning

The NRC has modelled the potential costs associated with ecological thinning in State Conservation Areas through an indicative ecological thinning program described in Table **26**.

Table 26: Indicative ecological thinning program

Ecological thinning program	Thinning intensity	
Program where areas of management concern (white cypress pine canopy percentage classes 2, 3 and 4) across four priority State Conservation Areas are actively managed (approximately 44,000 hectares)	**A**	Moderate (removal of 8 to 15 percent of standing volume)
	B	Heavy (removal of 20 to 35 percent of standing volume)

The modelled program is based on the assumption that all potential areas of management concern within the four priority State Conservation Areas are treated – Goonoo, Pilliga, Pilliga West and Trinkey (as identified in **Section 9.3**).

Within this program, there are two modelled variations in thinning intensity. The moderate thinning option aims to reduce the density of white cypress pine by removing 8-15 percent of the standing volume. This would promote the regeneration of groundcover, shrubs and tree species such as eucalypts, while also retaining and promoting the growth of white cypress pine trees. The heavy thinning option involves a greater reduction of white cypress pine, removing 20 to 35 percent of the standing volume, to provide even more potential to increase regeneration of groundcover, shrubs and other tree species.

In practice, however it is likely that any thinning program will target priority areas and apply varied thinning regimes to achieve a range of environmental objectives, thus reducing the extent and cost of the management program.

For the purposes of this analysis, the program assumes a seven year planning and implementation schedule, as outlined in **Table 27**. In total, around three percent of all State Conservation Areas would be potentially subject to ecological thinning in any year under this program.

Under this scenario, it is assumed the thinning intervention would be completed with machinery that would be adjusted to accommodate the size of white cypress pine trees being thinned, particularly where smaller logs are the focus of thinning activities. Machines provide an efficient and safe working environment for operators. Facilitating such an investment in machinery reconfiguration requires commitment to a program over a reasonable time period. The chosen program length is similar to that of previous non-commercial thinning programs undertaken by the (former) NSW State Forests in State Forests within the Brigalow and Nandewar Community Conservation Area.[35]

The NRC selected this time period to provide a practical means to model and calculate the potential costs of ecological thinning on a year-by-year basis. In practice, ecological thinning could continue over a longer time period, and over a larger or smaller area depending on the desired ecological objectives.

[35] This thinning program was undertaken as part of the NSW Government's Brigalow Initiative to promote ecological and timber value outcomes, and provide jobs for timber workers and local Aboriginal community members.

Table 27: Potential program of ecological thinning under varying scenarios

	Class 2	Class 3	Class 4	Total
Total area (hectares)	25,697	11,799	6,400	43,896
Approximate area treated per year over a seven year program (hectares per year)	3,671	1,686	914	6,271

The costs associated with the indicative ecological thinning program are shown in **Table 28** and the management costs, including assumptions, are shown in **Table 29**.

The NRC estimates that an ecological thinning program for the four priority State Conservation Areas would be in the vicinity of $2.5 million (for moderate levels of thinning) to $3.5 million (for heavy levels of thinning) across 6,271 hectares per year (totalling 43,896 hectares over seven years). If the total area being actively managed decreased, total program costs would also decrease.

These costs are premised on the program requiring 1-2 full-time equivalent employees (with relevant experience) providing on-going and direct supervision of contractors undertaking the thinning operations.[36] An accountability model that uses periodic audits rather than direct supervision would reduce overall program costs by up to 15 percent over seven years. Under this model overall annual program costs would be in the vicinity of $1.9 million for moderate levels of thinning to $3.5 million for heavy levels of thinning. This is the equivalent cost of $300 and $560 per hectare respectively. Under this model, contractors would work to a prescribed management plan focusing on outcomes and periodic risk based audits would be undertaken against these outcomes.

The indicative costs outlined in the following section and **Table 28** are based on adopting an outcomes based performance audit.

[36] Based on typical arrangements in forest harvesting operations such as checking tree marking and periodic on-site supervision.

Table 28: Indicative ecological thinning scenario costs per year (rounded)

	Class 2 (3,671 hectares/yr)		Class 3 (1,685 hectares/yr)		Class 3 (914hectares/yr)		Total (6,271 hectares/yr)	
Thinning intensity	**Moderate**	**Heavy**	**Moderate**	**Heavy**	**Moderate**	**Heavy**	**Moderate**	**Heavy**
Program manage-ment costs[37]	$180,000		$150,000		$150,000		$480,000	
Direct thinning costs[38]	$880,000	$1,900,000	$360,000	$780,000	$194,000	$350,000	$1,430,000	$3,030,000
per/ha	240	520	210	460	115	210	230	480
Overall program costs	$1,060,000	$2,080,000	$510,000	$930,000	$334,000	$500,000	$1,910,000	$3,500,000
per/ha	$290	$570	$300	$550	$200	$300	$300	$560

Program management costs

Active and adaptive management within State Conservation Areas should be established as part of an ongoing management function. As a result, the indicative costs take into account typical program management processes such as planning, data collection, monitoring, reporting, and operations.

The assumptions underpinning the estimated program costs are outlined in **Table 29.**

Table 29: Breakdown of indicative ecological thinning program management costs

Typical processes	Typical activities	Estimated costs	Key assumptions & comments
Planning	Development of program design, proposed activities, data requirements and resources, monitoring and evaluation processes. Environmental approvals under NSW and Australian Government legislation.	Given the potential area of management concern (up to 46,000 hectares over 7 years) assessed costs are in the vicinity of $6 - 9 per hectare for first year of the program.	Design process to draw from regional and agency expertise. Based on data supplied by the Office of Environment and Heritage and benchmarked against data from similar land management activities from other jurisdictions.

37 Annualised equivalent for planning and monitoring/operations management.

38 Direct costs primarily relate to in-forest thinning, with 10 to 20 percent direct programme costs assumed to involve transportation of production volume to processing centres.

Typical processes	Typical activities	Estimated costs	Key assumptions & comments
Accountability and assurance	Risk-based performance audit model including pre-audit meetings, audit plan, implementation, post-audit meetings, reporting and management response.	Potential efficiency gain of up to 15% over a direct supervision approach	Audits completed by agency staff with audit experience. Modelled for year 1 as the system is initially applied and finding 10 percent efficiency in years 2 and 3, and then a further 10 percent in the following four years of the program as contractor performance improves.
Review and response	Includes design, implementation and assessment of field sampling processes, development and implementation of remotely sensed data capture and analysis, monitoring assessments and reporting.	Given the potential area of management concern (up to 46,000 hectares), assessed costs are in the vicinity of $5 - 8 per hectare per year, including costs of data capture and analysis.	Review and reporting would be part of Office of Environment and Heritage's department-wide adaptive management activities, and would use regional and departmental staff.

Program management costs have been informed by advice from the Office of Environment and Heritage regarding the costs incurred in the establishment and field sampling components of current thinning and grazing trials within NSW. The cost estimates also include future spatial data capture, interpretation and analysis; particularly with respect to LiDAR and ADS40 data. These costs have also been benchmarked against data from similar land management activities from other jurisdictions.

The NRC believes program management costs could reduce over time as active and adaptive management processes become standard practice within NSW reserves and after any initial set-up costs have been incurred.

Direct thinning costs

Direct thinning costs relate to the actual process of removing white cypress pine trees by machinery under the two thinning intensity options. Implementation costs are the primary costs incurred under an ecological thinning program, and vary from $210 (for moderate levels of thinning) to $520 (for heavy levels of thinning) per hectare depending on the thinning intensity and density (cypress canopy percentage class).

The NRC considered various harvesting configurations and machine type options to derive an indication of the cost of completing this activity, particularly machinery and configurations already used within the region and those suitable for small tree operations.[39] The machine rate varied by stem density, thinning intensity, and the expected distribution of stem size. The cost also took into account the potential scale of operations, area treated and staffing requirements to implement the differing scenarios. Relative to machine thinning, manual (hand) thinning costs would be significantly higher, less efficient and present greater risks in terms of work safety.

[39] There are variety of machinery and configuration designed to handle sawlogs and small stems, and create a variety of products (woodchip, hog fuel and mulch). For example, chipping and flailing machines such as Precision Husky, Petersen and Morbark; Tigercat feller bunchers; and various logging machines (i.e Komatsu) with specialised felling heads such as Waratahs.

There may be opportunities to align ecological thinning activities within State Conservation Areas with thinning that may potentially be undertaken by Forestry Corporation of NSW on State Forests in the future. This could help reduce the cost of implementation by sharing resources and equipment costs.

11.1.2 Targeted grazing

To implement targeted grazing as part of an active and adaptive management regime, there may be increased administration and compliance costs to Government for grazing licences. For instance, compliance costs may be higher than those for grazing in State Forests to ensure ecological values are protected.

Internal fencing would also be required if targeted grazing is adopted. Fencing costs vary substantially according to soil conditions, slope and access arrangements. Permanent and gated fences can cost in the range of $9,000 to $12,000 per kilometre. Temporary lighter fences might reduce these costs but may be less effective.

Installing adequate water points would be an additional cost to Government if dams do not currently exist in the areas where targeted grazing is being considered.

The NRC has not estimated the total cost of targeted grazing in an active and management program given it is likely to be used in only limited circumstances such as in formerly grazed areas (where fencing and watering points already exist), or would be provided at the lessee's cost.

11.1.3 Prescribed fire

There is potential for additional costs to Government, beyond costs already being incurred to undertake prescribed burns and wildfire management in the State Conservation Areas. For example, prescribed fire could be used as a secondary intervention after ecological thinning to supress white cypress pine regrowth and maintain the desired state.

The NRC could not obtain accurate figures for prescribed burning currently undertaken in State Conservation Areas. Typical costs would include staff time for planning and undertaking the activity, and the purchase of capital equipment.

The NRC investigated the cost of prescribed fire in other jurisdictions and found that it varied between $50 and $300 per hectare. The cost typically reflected the complexity of the forests and landscapes where the activity occurred, the objectives of the fire regime, the available method, and the risks around suitable days for introducing and managing fire.

In general, the NRC found that lower costs related to larger scale fuel reduction burning of more simple forest types with relatively uniform drying patterns that provide managers with reasonable confidence of how the fire will behave. Prescribed burning in forests with diverse forest structure and composition usually incurs higher costs.

As such, the NRC considers that implementing prescribed fire under an adaptive management program could cost land managers a minimum of $50 per hectare given the forest types are relatively simple and occur within predictable drying patterns.

11.2 Cost recovery and sharing opportunities

The NRC recommends that Government seek to recover at least part of the costs of undertaking active and adaptive management.

Cost recovery opportunities are generally tied to current commercial opportunities for ecological thinning residues. As part of this Terms of Reference, the NRC investigated commercial opportunities for cypress thinning residues (for further discussion see **Attachment 16**). Currently, markets for ecological thinnings are limited to large stems that meet existing dimensions of sawlogs (referred to as production volumes) and smaller stems that could be used as landscaping products such as garden mulch and compost (referred to as non-production volumes). Commercial opportunities for bioenergy and biofuels are limited to the use of non-production volumes for electricity generation. However, there is potential for future growth in this sector.

11.2.1 Cost recovery opportunities associated with ecological thinning

The NRC considers there are two primary opportunities to recover costs associated with ecological thinning in the State Conservation Areas:

- **'Cost recovery scheme' -** where the land manager incurs the cost of program management and the direct cost of the thinning intervention, and offsets the cost of thinning by revenue generated from the sale of material.
- **'Goods for services scheme' -** where the land manager incurs the cost of program management with the direct costs and commercial benefits of thinning being fully or partially transferred to an external party.

Cost recovery scheme

Under this scheme, the land manager would incur the direct costs of thinning. The costs could then be offset by revenue generated from the sale of thinning material which has a commercial value.[40]

Potential revenue generated from production volumes are presented in **Table 30**. These cost recovery estimates assume that the mills pay the equivalent price for this material as they currently do from State Forest white cypress pine sawlog supplies.[41] The costs incurred by State Conservation Area managers therefore include the cost of conducting the thinning and the cost of transporting the material to the two sawmills.[42]

Taking these cost recovery opportunities into account, the indicative overall annual program costs are estimated to be in the vicinity of $1.3 - $2.0 million per year, depending on the size of the treated areas and the thinning intensity.

The assessment indicates the ecological thinning program could recover between 30 percent to 40 percent of the total program costs. Some ecological thinning regimes could recover cost by up to 50 percent (for example heavy thinning in class 4).

40 The number of stems thinned and removed is the primary driver of cost. Under heavy thinning, more stems are thinned and removed per hectare. As such, cost recovery for production volumes (sawlogs) is less than the additional cost of thinning a greater proportion of smaller stems.

41 Price supplied in-confidence to the NRC by Forestry Corporation of NSW.

42 Modelling assumes current equivalent mill door price including stumpage and harvest and haulage charges.

Table 30: Potential for cost recovery under ecological thinning scenarios (rounded)

	Class 2 (3,671 ha/yr)		Class 3 (1,686 ha/yr)		Class 4 (914 ha/yr)		Total (6,271 ha/yr)	
Thinning intensity	Moderate	Heavy	Moderate	Heavy	Moderate	Heavy	Moderate	Heavy
Total program costs[43]	$1,060,000	$2,080,000	$510,000	$930,000	$334,000	$500,000	$1,910,000	$3,500,000
Cost recovery estimates (revenue)	$290,000	$740,000	$167,000	$425,000	$109,000	$276,000	$566,000	$1,441,000
Overall program costs with cost recovery	$770,000	$1,340,000	$340,000	$505,000	$235,000	$224,000	$1,350,000	$2,070,000
Per hectare	$210	$365	$200	$300	$260	$250	$210	$330
Proportion of costs recovered	25%	35%	30%	45%	30%	50%	30%	40%

[43] Includes cost of thinning and delivery of production volumes.

Land managers could offset the direct costs of ecological thinning more fully by adjusting the ratio of production to non-production logs to ensure a cost-neutral outcome. This could provide the necessary commercial incentive to engage a party for thinning services, particularly where smaller trees are to be thinned.

The NRC estimates up to 3 cubic metres of large trees with production value (over 12 metres in height) would need to be thinned for every 1 cubic metre of small trees with non-production value (less than 12 metres in height) would need to be thinned to approach full cost recovery) (**Table** 31). This compares with the scenario described above, where around 0.6 cubic metres of large trees with production value would be thinned for every 1 cubic metre of small trees with non-production value.

A full-cost recovery scenario is unlikely to be used at a large scale whilst achieving environmental outcomes. However, it provides useful benchmarks for land managers to consider in developing cost-efficient strategies and could potentially enable more area to be treated.

Cost recovery estimates for non-production volume arising from ecological thinning in State Conservation Areas are less certain due to the lack of an established market at present for these residues. To improve cost recovery, a potential option is to combine an ecological thinning program in State Conservation Areas with a similar program in State Forests.

Table 31: Potential for full cost recovery under ecological thinning scenario

Volume (cubic metres per year)	Class 2 (3,671 ha/yr)	Class 3 (1,686 ha/yr)	Class 4 (914 ha/yr)	Total (6,271ha/yr)
Production volume (m^3/yr)	14,537	8,344	5,431	28,312
Non-production volume (m^3/yr)	4,361	2,781	1,810	8,952
Cost recovery estimate ($/program/y)	$1,450,000	$835,000	$540,000	$2,825,000

Goods for services scheme

Under a goods for services scheme, goods in the form of forest products are traded for services, in this case ecological thinning. In the United States, such schemes often involve the removal of trees and biomass for improved forest health or fire fuel reduction (Stephens, 2013). The party undertaking the services receives the benefits of any product for free.

The goods for services scheme seeks to:

- provide flexibility to the land manager to secure ecological services while minimising administration costs in collecting revenues
- secure best value for services based on evaluation processes that weigh up overall program objectives and priorities
- secure a range of multiple and concurrent environmental and social benefits such as weed control, native vegetation restoration, and road and trail maintenance.

Overall, this type of approach places more importance on the ecosystem benefits and outcomes that are achieved, instead of on the products that are removed (United States Department of Agriculture Forest Service, 2009a). However, where the value of goods removed exceeds the value of services provided, the additional value is credited towards other stewardship activities.

The United States Forest Service and Bureau of Land Management have been implementing a similar scheme based on stewardship contracts and agreements since 2003 (United States Department of Agriculture Forest Service, 2009b). Over 1,400 contracts and agreements have been initiated across all States (Pinchot Institue for Conservation, 2014). **Table 32** lists the legislated goals for stewardship contracts in the United States.

Table 32: Legislated[44] defined land management goals in the United States for stewardship programs (Pinchot Institute for Conservation, 2014)

Goals of stewardship contracts and agreements
▪ Maintaining or removing roads and trails to restore or maintain water quality
▪ Maintaining soil productivity, habitat for wildlife and fisheries, or other resource values
▪ Prescribed fires to improve the composition, structure, condition, and health of stands or to improve wildlife habitat
▪ Removing vegetation or other activities to promote healthy forest stands, reduce fire hazards, or achieve other land management objectives
▪ Restoring or maintaining watersheds
▪ Restoring or maintaining wildlife and fish habitat
▪ Controlling noxious and exotic weeds, and re-establishing native plant species

The contracts are outcomes-focused and can be in place for up to 10 years. This adds value to forest products such as biomass for energy generation, as this type of resource needs certainty of supply to encourage investment. Contracts are awarded on 'best-value' rather than strict revenue generation (U.S. Department of the Interior, 2013).

44 Public Law 108-7

It is difficult to estimate the overall costs of an ecological thinning program under a goods for services scheme in the State Conservation Areas at this point of time. There would be an initial upfront investment to establish an appropriate operating framework. Ongoing costs would include administration and program management costs, such as processes to identify and collaborate with potential service providers, and assurance costs to ensure environmental objectives are met.

However, the NRC believes the goods for services scheme could further reduce overall program costs compared to the cost recovery options described above. This is because direct thinning costs would be borne by the external party commissioned to undertake the services for thinning material. The scheme also provides the external party with an incentive to further develop markets for material that currently has relatively low market value compared to sawlogs (such as small trees).

Using the previous options described above, the NRC estimates that overall program costs of a goods for services scheme could range:

- from $40 per hectare (lower range) – this assumes full cost recovery as described in
- **Table** 31, where the land manager incurs the full cost of program management and the direct costs and benefits are incurred and accrued by the party undertaking the services
- up to $210 per hectare (upper range) – this assumes a partial cost recovery as described in **Table 30**, where the land manager incurs the full cost of program management and partial costs for undertaking the activity.

These are indicative figures only, and the actual overall program cost is likely to fall between the lower and upper range. It is important to note, this option would need sufficient commercial incentive to engage a neutral party for ecological thinning. For example, the thinning regime would need to include a certain amount of larger trees (production volume) to make the activity commercially attractive.

11.2.2 Other cost recovery avenues

Variable stumpage rates

The NSW Government may wish to explore alternative pricing mechanisms to increase cost recovery for active and adaptive management in State Conservation Areas. For example, instead of a single stumpage rate for all logs which meet the sawlog dimension, the NSW Government may wish to explore a more variable rate that takes into account the size of the logs being delivered. An arrangement in which a higher price is paid for larger logs may allow a higher rate of cost recovery while still allowing local sawmills access to additional resource. However, this would involve additional costs to the manager in measuring logs.

Grazing

Cost recovery opportunities from grazing interventions would be limited to revenue generated by grazing permits. For example, the Forestry Corporation of NSW receives approximately $18,000 in total rental fees for 33 grazing permits, averaging $2.80 per hectare for its existing licences (Forestry Corporation of NSW, pers. comm., December 2013). Charging commercial rates for any grazing licences would further contribute to the amount of cost recovered for this activity.

There is no cost recovery avenue directly associated with prescribed fire interventions.

Box 5: Thinning regimes and commercial opportunities for cost recovery

Thinning regimes

The thinning intensity was set at removing 8-15 percent of the standing white cypress pine volume for a moderate thinning program, and 20-35 percent of the standing white cypress pine volume removed for a heavy thinning program.

These intensities take into account the LiDAR measures of stems per hectare for the differing tree heights (>12 metres, 3-12 metres, <3 metres tall), and estimated production and non-production volume per hectare, where production volume is trees of a dimension equivalent or larger than current industry sawlog specifications, and non-production volume is trees >3 metres tall but smaller than the current sawlog specifications.

Sawlogs

The NRC has analysed ADS40 and LiDAR data to estimate the potential available annual production[45] and non-production[46] volumes that might arise from the ecological thinning in four priority State Conservation Areas – Goonoo, Pilliga, Pilliga West and Trinkey State Conservation Areas (see table below**).**[47]

These volumes assume that ecological thinning is primarily completed through mechanical thinning. Some level of white cypress pine crowns and branches should be retained on the ground to maintain coarse woody debris levels in thinned areas. However, the preferred level for ecological purposes is unknown in these forest types and should be determined under an active and adaptive management program. These volume estimates are indicative only, and actual volumes arising could vary markedly both within a year and between years in a program.

Volume (cubic metres per year - rounded)	Class 2		Class 3		Class 4		Total	
Thinning intensity	**Moderate**	**Heavy**	**Moderate**	**Heavy**	**Moderate**	**Heavy**	**Moderate**	**Heavy**
Production volume	3,000	7,400	1,700	4,200	1,000	2,700	5,700	14,300
Non-production volume	4,300	11,100	2,800	7,000	1,800	4,600	8,900	22,700

Landscaping products

The market for landscaping products, including mulch and composts, is a high volume market but not well reported in terms of its size, production base, demand drivers or price. Due to the low value of the product, it tends to be produced and supplied regionally where transport distances to market can be minimised. While the market is likely to be relatively consistent in annual terms, it is reportedly highly seasonal, particularly between cooler and warmer months.

An existing landscaping operation at Gunnedah is mainly securing timber residues produced by the Gunnedah and Baradine sawmills. This firm has indicated it has opportunities to increase its supply of cypress-based landscaping products, and the market for garden mulch and composts is growing. The potential for this firm to pay the costs incurred in extracting and delivering non-production grade ecological thinning residues from State Conservation Areas is not tested.

For further discussion of commercial opportunities regarding landscaping products see **Attachment 16**.

45 White cypress pine trees greater than 12 metres in height.
46 White cypress pine trees between 3 and 12 metres in height.
47 White cypress pine trees found in potential environmentally and culturally sensitive areas have been excluded from estimated gross volumes.

12 Implications for industry and local communities

Key points

KP 12.1 If commercial use of the by-product of ecological thinning is permitted, ecological thinning will provide a benefit to local timber businesses and communities, particularly those of Baradine and Gwabegar given their strong links with the timber industry. The level of benefits will depend on the extent and intensity of these interventions.

KP 12.2 Ecological thinning that is carried out without commercial use of by-products will provide smaller benefits to local communities.

KP 12.3 The relatively robust, diverse regional economy and the minor scale of change anticipated from active and adaptive management mean these benefits are likely to be insignificant at a wider regional level.

This chapter explores the potential social changes resulting from active and adaptive management in State Conservation Areas in the Brigalow and Nandewar region, including likely changes to local industries, neighbouring landholders, local communities, Aboriginal communities, cultural values and the regional economy.

12.1 How social change can affect communities

Active and adaptive management in State Conservation Areas has the potential to be a source of social change in the Brigalow and Nandewar region. The magnitude and type of change resulting from active and adaptive management depends on where management activities occur and their likely nature, extent and duration.

Any source of change in a social system may have a direct or indirect (flow-on) effect throughout the system (Boudon, 1986). As shown in **Figure 24**, these changes can occur within an industry, or at the individual, household, community or regional scale. Social change is an ongoing process occurring at the regional, community, household and individual level over time.

Figure 24: Effects of change on the social system

A vulnerability framework provides a useful way of understanding how people respond and adapt to change (Allen Consulting Group, 2005; Nelson et al., 2007; Smit & Wandel, 2006). The extent to which local communities in the Brigalow Nandewar region are vulnerable to active and adaptive management of State Conservation Areas depends on their:

- **exposure**: the level of change to which a community is likely to be exposed; for instance, the nature, extent and duration of change
- **sensitivity**: the dependency or reliance of a community on the attribute that is changing (Gallopin, 2006); for instance, communities that depend on natural resources are sensitive to changes in management practice that increase or decrease the supply of these resources (Stedman et al., 2004).

12.2 Local industries

12.2.1 Timber industry

Active and adaptive management in the State Conservation Areas is likely to benefit the timber harvesting, transport and processing sector. Benefits are likely to be largely opportunistic due to the variability of timber supply and the additional costs of timber harvesting, delivery and processing. Ecological thinning that is carried out without commercial use of by-products will provide smaller benefits to local communities.

For example, using the NRC's modelled scenarios for priority State Conservation Areas, the production volume could vary from 1,000 cubic metres per year (if only the densest class is treated) to 14,000 cubic metres per year (if all dense classes are treated) (**Box 5, Section 11.2.2**).

The NRC has investigated alternative uses for timber obtained from an ecological thinning program, and considers that the program could feasibly supply stems that are suited to sawing and meet sawlog dimensions (from production volume) and smaller stems that are not suited for sawing and therefore could be used in low value products such as mulch, compost and bark (from non-production volume). This material could be used by the local timber processing

industry (see **Attachment 16** for further discussion of commercial opportunities arising from ecological thinning).

Sawmilling operations

The Brigalow and Nandewar sawmilling industry comprises two cypress sawlog processors located in the towns of Baradine and Gunnedah. The mills process a range of solid wood products that are sold primarily into NSW and Victorian domestic markets. An NRC survey conducted in November 2013 indicated the Baradine sawmill has 14-16 employees and the Gunnedah mill has 15-19 employees operating on a single shift.

The production volume at the upper range of the NRC's modelled scenarios would result in a significant increase in supply to the local sawmill industry. However, benefits to the mills would vary depending on the extent and intensity of the ecological thinning program, the size and quality of logs generated from thinnings, and market conditions.

In public submissions, the local sawmilling industry indicated that it will be forced to close without the additional supply of larger logs (Gunnedah Timbers Pty Ltd, 2012). The NRC understands that the two local cypress timber mills in Baradine and Gunnedah are currently operating on low gross margins, and that the current volume of wood supply is at the lower end of wood supply agreements (Forestry Corporation of NSW, pers. comm., 2013).

If the mills take up additional production volume from ecological thinning, this has the potential to enhance viability by improving the use of capital and providing the mills with a better log mix. Improvements to the mills' production levels could also lead to the number of hours worked by employees increasing from part-time to full-time, resulting in increases in employee and household income.

An NRC survey of timber industry employees for this review indicates the majority of employee and household expenditure would occur in the towns of Baradine and Gunnedah, with indirect flow-on effects to nearby towns and regional centres. Minor expenditure would also occur in nearby centres such as Coonabarabran, Dubbo and Tamworth.

However, in practice, increased employment is likely to be sporadic and small scale due to the variable volumes and timing of high quality logs from year-to-year.

While the local sawmilling industry is capable of processing smaller sawlogs, the production process will be less efficient as its equipment is not suited for this type of cutting. This results in lower gross margins on typical small log products. For the mills to implement efficient processing, they would need to move into a more specialised "small sawlog line" which would have significant upfront costs.

Piece size and volume have a significant influence on harvesting costs and the final delivered cost of logs to sawmills. Harvesting and haulage of non-production volumes would increase harvesting costs and therefore the price of delivered logs to the mills.

Harvest and haulage operations

The local harvest and haulage industry consists of two firms who supply production volumes to the Baradine and Gunnedah sawmills under the mills' existing wood supply agreements with Forestry Corporation of NSW. An NRC survey conducted in November 2013 indicated that one harvest and haulage firm is based in Baradine with four employees, and the other is based in Gunnedah and employs three people. Both firms operate a mechanised harvesting system.

The harvest and haulage industry is likely to receive the greatest benefits from an ecological thinning program, as it could be directly engaged to implement core program elements such as thinning and the removal of timber, regardless of whether the timber has a commercial use.

Increases in production and/or non-production volumes for harvesting and transport could improve the efficiency of harvesting and haulage operations by allowing these firms to operate at full capacity. For example, a local harvest and haulage firm reported as part of this review that it is working at around 60 to 70 percent of potential capacity, due to a combination of the small average volume of individual logs, low yields per hectare and low delivery schedules.

The more efficient use of capital as a result of additional production and non-production volumes required to be thinned, and the potential additional benefit of transporting this material, are likely to result in an increase in hours worked by existing employees. This would lead to minor increases in expenditure in Baradine, with indirect flow-on effects to nearby towns and regional centres. Minor expenditure would also occur in nearby centres such as Coonabarabran and Dubbo.

Machinery used to harvest trees in an ecological thinning program would need to be re-adjusted to recognise the greater proportion of small, short trees being removed, and the density of these stems within each hectare being treated. This would require upfront capital investment by harvest and haulage operators.

Landscaping industry and other processors

There is one landscaping firm based in Gunnedah that is owner-operated. The firm purchases bark and other low value products from the Gunnedah and Baradine mills for reprocessing and selling to wholesale markets.

Benefits to the local landscaping operation from ecological thinning are likely to be minimal, as it would be directly incurring the costs of harvesting and transport to the Gunnedah site (see **Box 5, Section 12.2**). Harvesting and haulage costs for smaller log sizes would be greater than for larger logs, which would increase the price of delivered logs. The potential for this firm to pay these additional costs is not tested.

If Forestry Corporation of NSW were to establish a thinning program in State Forests for non-production size logs, integrating this program with ecological thinning in the State Conservation Areas could lead to greater benefits via more cost efficient use of harvest and haulage operators. However, Forestry Corporation of NSW has yet to find commercially viable opportunities for thinning smaller logs in State Forests.

Local firewood operators are likely to obtain minimal benefits from an increase in the supply of non-production volumes due to the limited potential for cypress to be used as a firewood species.

Bioenergy and biofuels sector[48]

The most promising commercial opportunity for the use of non-production material generated by ecological thinnings is electricity generation. While markets are developing for the use of biomass as fuel, commercial opportunities are limited at present.

48 The discussion in this section is based on a report prepared for the NRC by Enecon Pty Ltd, June 2014.

A co-generation plant at the Gunnedah or Baradine sawmill could reduce utility costs and provide a revenue stream if excess electricity is sold to the national grid. If the use of this additional non-production volume also increases mill production levels, this could lead to an increase in the number of hours worked by employees and associated minor increases in employee and household income and expenditure. However, an ecological thinning program in State Conservation Areas would need to be integrated with a thinning program in State Forests to generate sufficient forest biomass for co-generation.

The ability to pursue this commercial opportunity is currently prevented by legislative barriers to the use of native forest pulpwood and residue as a renewable energy source at the state and national level (for a more detailed discussion see **Section 13.2**). The Australian Government is currently reviewing the Renewable Energy Target scheme (Department of Prime Minister and Cabinet, 2014).

More work is also required to investigate the feasibility of co-generation using non-production volumes. Additional off-grid and cogeneration opportunities within the Brigalow and Nandewar region are limited by lack of customer demand, alternative biomass and fuel supplies (such as cotton waste and coal), and the capital cost of a cogeneration plant. Supplying biomass to bioenergy operations outside of the region is likely to be unfeasible given the transport costs involved.

12.2.2 Grazing industry

The use of targeted grazing as a management tool in State Conservation Areas is likely to be limited and opportunistic, and thus provide minimal benefits to the grazing industry.

White cypress pine forests are typically held in low demand by graziers due to low quality feed, poor access to the forest for husbandry oversight, and difficulty in mustering. Benefits will most likely be limited to those graziers in close proximity to relevant State Conservation Areas, or who are able to agist livestock in these areas.

A minor increase in livestock production values is unlikely to lead to any increases in direct or indirect employment, as margins in this industry are already relatively low (Australian Bureau of Agricultural and Resource Economics and Sciences, 2013). The value of grazing in State Conservation Areas may well be supplementary when there is a shortage of feed elsewhere.

Benefits to graziers would need to be offset against grazing permit charges; for example, Forestry Corporation of NSW receives approximately $18,000 in total rental fees for 33 grazing permits (Forestry Corporation of NSW, pers. comm., December 2013). Any potential benefit would also need to be offset against additional overheads, including the costs of transport and the construction and maintenance of infrastructure including fences and watering points.

12.2.3 Apiary industry

In the short term, ecological thinning, targeted grazing and prescribed fire have the potential to reduce access to apiary sites if activities occur close to hives. This can have direct impacts on the viability of apiarists (Somerville, 1997), and can also have flow-on effects to other apiarists by increasing competition for remaining floral resources (Somerville, 1997). Targeted grazing and prescribed fire may also have minor negative impacts on flowering species used by bees for honey production and pollen.

Impacts could be greater in the short term as the majority of apiculture activity occurs in Pilliga and Goonoo State Conservation Areas (see **Section 4.4.8)**, which are recommended as a priority

for active and adaptive management. Goonoo has previously been identified as being particularly valuable for apiary due to its size (Somerville, 1997; Curby & Humphries, 2002).

In the long term, ecological thinning may result in marginal benefits to the apiary industry. For example, potential increases in eucalypt regeneration, and reduced eucalypt dieback and mortality (Cameron, 2003) could increase honey production from existing hives. Increased diversity of flowering species as a result of grazing and prescribed fire could have similar benefits.

The Office of Environment and Heritage (National Parks and Wildlife Service) should consult with the apiary industry regarding risks to apiary sites in Goonoo and Pilliga State Conservation Areas. Plans of management should aim to reduce the likelihood of access issues near key apiary sites during peak flowering periods of relevant species and during agricultural spraying periods in the broader region.

12.2.4 Other potential effects

Prescribed burns are already being undertaken in State Conservation Areas. There may be additional small-scale sporadic opportunities for employment and training in fire management if the Office of Environment and Heritage (NSW National Parks and Wildlife Service) uses external contractors.

There may also be small scale employment and training opportunities with the Office of Environment and Heritage for other components of the active and adaptive management program such as planning, administration, monitoring and evaluation (See **Section 11.1.1**). Depending on the type of employment, opportunities may be available in towns such as Baradine and Narrabri where Office of Environment and Heritage (NSW National Parks and Wildlife Service) offices are located.

12.3 Sensitive local communities

Figure 25 shows the local communities in close proximity to State Conservation Areas identified as a priority for active and adaptive management (Pilliga, Pilliga West, Goonoo and Trinkey) are: Baradine, Coonabarabran, Dubbo, Gunnedah, Gwabegar and Narrabri.

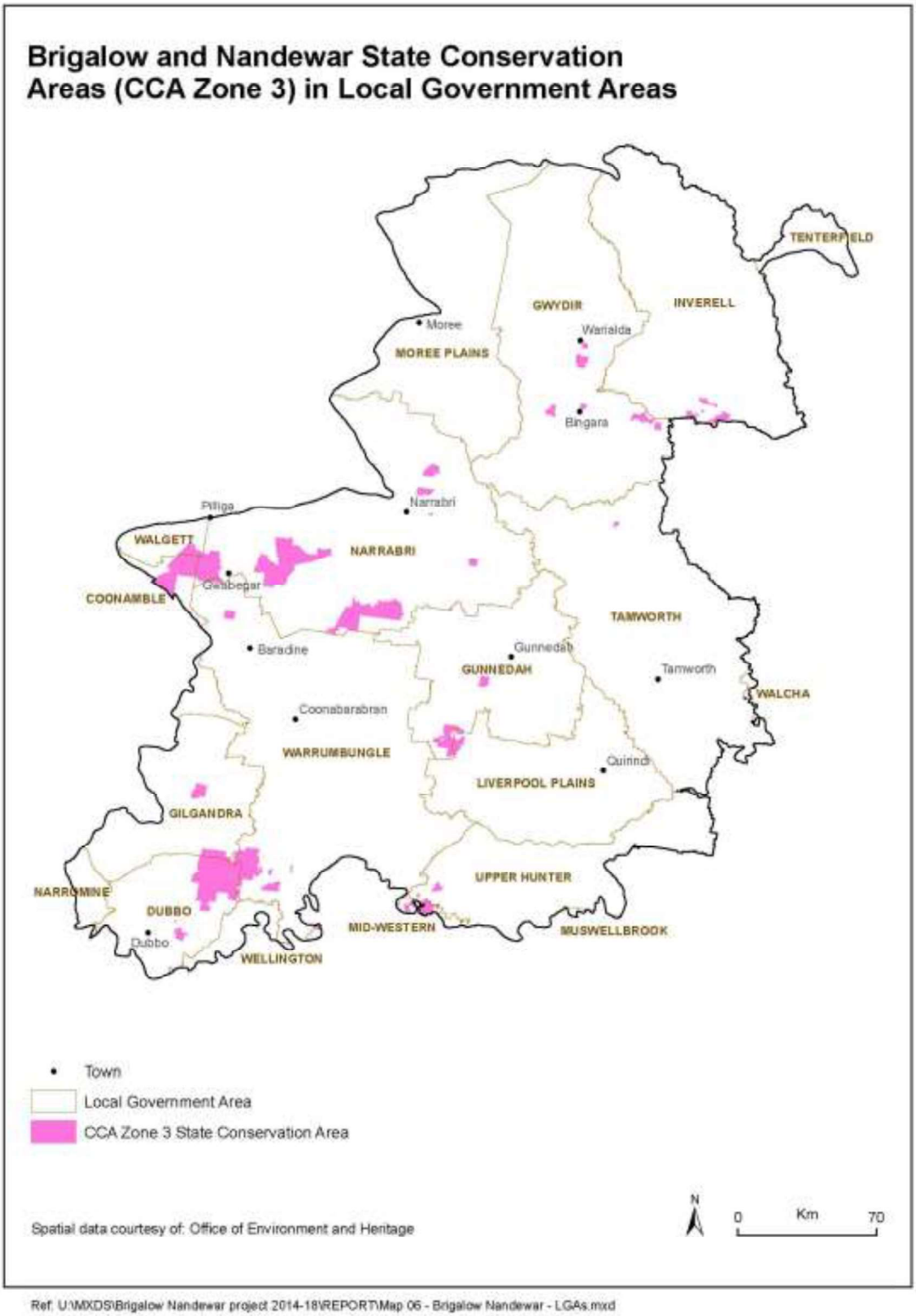


Figure 25: Map showing Local Government Area boundaries

Ecological thinning is likely to contribute to improvements in the resilience of Gwabegar and Baradine, as these communities have low industry diversity and are sensitive to increases in the timber industry's viability. The extent of these benefits will depend on the extent and intensity of the ecological thinning program, the size and quality of logs, and market conditions.

In contrast, ecological thinning is likely to result in minimal benefits for larger regional centres such as Tamworth, Dubbo, Gunnedah and Coonabarabran, as these communities have more diverse economies and are less sensitive to changes in the timber industry.

Economic diversity is a useful indicator of resilience to downturns or shocks and is a way of indicating a community's capacity to absorb change to the structure and operation of particular industries (Hassall & Associates Pty Ltd, 2004). Low industry diversity indicates a specialised economy, which is more likely to be affected by change in a particular industry. For example, communities that depend on natural resources are sensitive to changes in management that increase or decrease the supply of those resources (Stedman et al., 2004).

Figure 26 shows the industry diversity of selected towns in the Brigalow Nandewar region. Baradine and Gwabegar have the lowest industry diversity and are most likely to be affected by active and adaptive management.

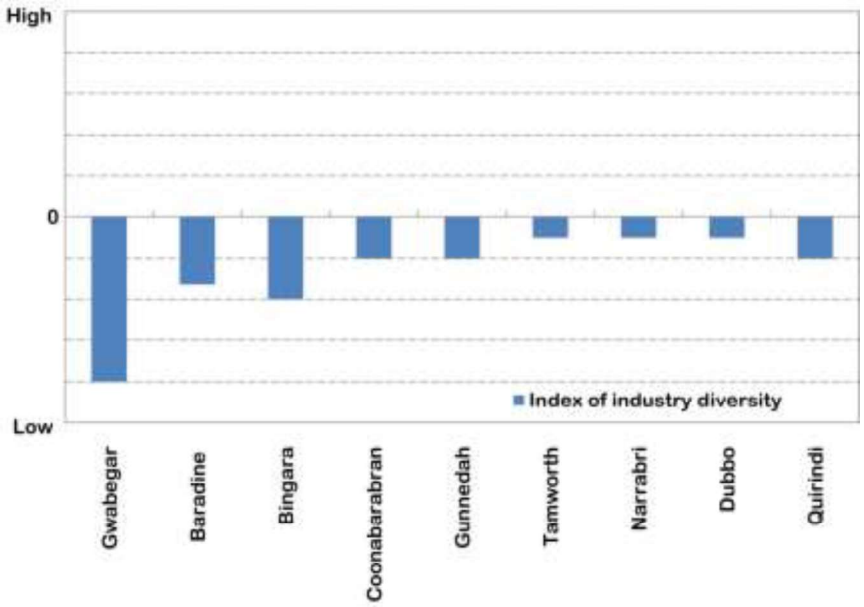


Figure 26: Index of industry diversity of selected towns in the Brigalow Nandewar region (Herfindal Index) (Australian Bureau of Statistics, 2011a)

Baradine is highly dependent on the timber industry, for example:

- the agriculture and forestry sector is the highest source of employment in Baradine (19.8 percent) (Australian Bureau of Statistics, 2011a)
- a sawmill and an integrated harvest and haulage operator are major employers in Baradine. As discussed in **Section 12.2**, these firms employ 20 people who all reside in Baradine
- during the cypress thinning program funded by the Brigalow Assistance Fund as part of the establishment of the Brigalow and Nandewar Community Conservation Area in 2005, employment in agriculture and forestry increased to 31.8 percent (Australian Bureau of Statistics, 2006a).

Gwabegar is sensitive to changes in the timber industry due to its dependence on Baradine as the closest location for services and its already high unemployment rate (which increased from from 8.2 percent in 2006 to 11.8 percent in 2011) (Australian Bureau of Statistics, 2001, 2006a, 2011a). While Bingara also has low industrial diversity it is less dependent on the timber industry (Australian Bureau of Statistics, 2011a).

Even with high levels of exposure and sensitivity to change, communities that can cope with the change will remain resilient. In contrast, communities with limited adaptive capacity will be more vulnerable to future changes that are likely to occur (Allen Consulting Group, 2005). Adaptive capacity is the extent to which the community is able to adapt or cope with the change that is occurring (Nelson et al., 2007).

Gwabegar and Baradine have low adaptive capacity relative to other towns in the region, as is evident in the indicators of child dependency and low industry diversity (Australian Bureau of Statistics, 2011a).

Minor increases in household income, expenditure and employment are likely to lead to positive changes to the resilience of Baradine and Gwabegar, given these towns' high sensitivity to changes in the timber industry and low capacity to adapt to change. These improvements in resilience may mean that Baradine and Gwabegar avoid further social decline, and maintain current workforce capabilities in the timber industry and community connection to the forests.

12.3.1 Other local communities

In contrast to Baradine and Gwabegar; Gunnedah, Coonabarabran, Dubbo and Tamworth are less sensitive to changes in the timber industry due to their greater industry diversity and higher capacity to adapt to change (**Figure 26**).

Of these towns Gunnedah has stronger links to the timber industry; for instance, a sawmill and a harvest and haulage operator are based in Gunnedah. As discussed in **Section 12.2**, these firms employ 30 people. A local landscaping firm which purchases low value products from the Gunnedah and Baradine sawmills for further processing is also located in Gunnedah.

However, in Gunnedah, retail trade, followed by health care and mining are the highest sources of employment (11.5 percent, 10.2 percent and 8.5 percent respectively) (Australian Bureau of Statistics, 2011a). In particular, mining has become increasingly important in the Gunnedah Basin (see **Section 12.6.2** for further discussion) (Narrabri Shire Council, 2007, 2009; Parsons Brinckerhoff Pty Limited, 2008).

Active and adaptive management also has some potential to affect Coonabarabran, Dubbo and Tamworth, as timber industry employees' expenditure also occurs in these towns. However, benefits are likely to be negligible in Tamworth and Dubbo due to the relative robustness of their economies. For example, the Tamworth and Dubbo Local Government Areas have the largest share of the Brigalow Nandewar total Gross Regional Product - Tamworth has $2.7 billion followed by Dubbo with $2.2 billion (Australian Bureau of Statistics, 2012, 2011b). The main economic drivers in Dubbo and Tamworth Local Government Areas are local services such as health care and social assistance, retail trade, financial services and education rather than agriculture, forestry and fishing (Australian Bureau of Statistics, 2012, 2011b).

Coonabarabran is also not particularly sensitive to economic change due to its more diverse industrial base (**Figure 26**) and relatively average employment levels (Australian Bureau of Statistics, 2006a, 2011a).

12.4 Aboriginal communities and cultural values

12.4.1 Aboriginal cultural heritage

If active and adaptive management is implemented in priority State Conservation Areas (Pilliga, Pilliga West, Goonoo and Trinkey State Conservation Areas), it may affect communities represented on the Pilliga Gawambaraay Co-Management Committee, the Coonamble, Dubbo, Gilgandra, Pilliga, Walgett, Wee Waa and Walhallow Local Aboriginal Land Councils, the Tubba-Gah people and the Gomeroi people. See **Figure 6, Section 4.4** for a map showing the location of State Conservation Areas in relation to Local Aboriginal Land Council boundaries.

In the short term, active and adaptive management has the potential to restrict Aboriginal access to Country and culturally significant sites and plants. Targeted livestock grazing and prescribed fire may damage culturally significant plants and sites in the short-term, if not appropriately managed.

Ecological thinning activities, such as the use of harvesting and haulage machinery may have long-term impacts on Aboriginal sites through ground surface disturbance. While risks may increase slightly in alluvial landforms due to the higher archaeological potential of these areas (NSW National Parks and Wildlife Service, 2002a), white cypress pine tends not to be dominant in archeologically sensitive landforms (Office of Environment and Heritage, pers. comm., April 2014). Tree felling also has the potential to impact trees with cultural markings.

Impacts may be significant in the Goonoo State Conservation Area, which the Tubba-Gah people have identified as being of very high cultural significance. The Goonoo State Conservation Area also has the highest number of registered sites (**Attachment 12**).

In the long term, improved environmental values as a result of all active and adaptive management options have the potential to increase the availability of culturally significant plants. Prescribed burns may also reduce the long term risk of wildfires to Aboriginal cultural heritage.

Potential impacts on Aboriginal cultural heritage can be managed by complying with existing regulatory requirements and NSW procedures on cultural heritage management (see **Section 13.2.4**). For instance, if sites occur near creeks these will be excluded from active management based on existing environmental and cultural management prescriptions.

12.4.2 Aboriginal employment

Active and adaptive management has the potential to provide small-scale employment and training opportunities to Aboriginal people in cultural surveys and assessments. Aboriginal people have historically been employed in the timber industry (Curby & Humphries, 2002) and there may be some opportunities for Aboriginal people to be employed as harvesting and haulage contractors.

There may be additional employment and training opportunities in fire management. Aboriginal employment in the NSW public service is a NSW Government priority (NSW Aboriginal Affairs, 2013).

12.5 Effects on and around State Conservation Areas

12.5.1 Recreation and amenity

All active and adaptive management options may have short-term minor negative impacts on amenity and recreational use, due to:

- restricted access during operations for recreational activities such as bushwalking and bird watching
- increased noise resulting from harvesting and haulage machinery, human activity, vehicle movements and road requirements
- reduced visual amenity if residues from ecological thinning, particularly larger logs, are retained on-site, and after prescribed burns have been undertaken.

Ecological thinning and grazing may also conflict with visitor expectations regarding permissible activities in these State Conservation Areas, including the intrusion of mechanised equipment such as timber harvesters and the presence of livestock. Stakeholder submissions have already raised concerns about the impact of these activities on the recreation and amenity values of these areas.

Impacts may be marginally greater in the Pilliga and Goonoo State Conservation Areas, as they experience higher visitation levels than other State Conservation Areas and are recommended as a priority for active and adaptive management.

However, as noted in **Section 4.4.4,** the majority of tourism visits in the region occur in national parks that are in close proximity to caves or cultural sites, rather than State Conservation Areas (NSW National Parks and Wildlife Service, pers. comm., 1 November 2013).

In the longer term, active and adaptive management has the potential to lead to an overall marginal benefit to visitor experiences and recreation levels, based on improved environmental values of these areas.

12.5.2 Historic heritage

Many of the Brigalow and Nandewar State Conservation Areas have historically been used for grazing and forestry, and therefore grazing and ecological thinning are not expected to have major impacts on the remaining items of historic heritage.

Prescribed burns are already being undertaken in State Conservation Areas. As such, any changes in the scale, frequency or distribution of prescribed burns will result in limited impacts on historic heritage. In the long-term, low intensity prescribed burns may reduce the risk of wildfires to historic heritage sites.

As noted in **Section 4.4.7**, the Goonoo State Conservation Area has the highest number of historic heritage items and places (10), followed by Pilliga West State Conservation Area (nine). Management of potential impacts of active and adaptive management on historic heritage should be consistent with regulatory requirements for heritage assessment and approval (see **Section 13.2.3**).

The potential impacts of active and adaptive management on Aboriginal cultural heritage and the Aboriginal community are considered in **Section 13.2.4**

12.5.3 Neighbouring landholders

Active and adaptive management has the potential to have short-term marginal negative impacts on neighbouring landholders due to:

- increased noise resulting from harvesting and haulage machinery, human activity, vehicle movements and road requirements
- reduced visual amenity associated with on-site retention of residues from ecological thinning, particularly larger logs
- livestock damage to boundary fencing or escape into neighbouring properties.

The use of prescribed fire could result in significant negative impacts if burns are not adequately controlled and fire escapes into neighbouring properties.

Stakeholder submissions have identified that thick stands of cypress that are not actively managed are associated with smaller tree sizes, increased number of feral pests, a decline in native wildlife and limited groundcover. In the longer term, active and adaptive management could provide benefits to park neighbours by addressing the issues associated with dense stands of cypress.

The application of prescribed fire may reduce the risk of uncontrolled fires in State Conservation Areas impacting on neighbouring properties. Active and adaptive management also has potential in the long-term to lead to an overall marginal benefit to visual amenity based on improved environmental values of these areas.

Management strategies should give adequate notice to neighbouring landholders of Pilliga, Pilliga West, Trinkey and Goonoo State Conservation Areas regarding operational activities.

12.6 Effects on the region

12.6.1 Resilience of the region

Social change as a result of the introduction of ecological thinning, targeted grazing and prescribed burns is likely to be insignificant given the:

- region's low dependence on the timber industry
- small scale of the expected change
- relative resilience of the regional economy.

The economic environment of the Brigalow Nandewar region is relatively robust and driven by the agriculture, health care, manufacturing and education sectors (Australian Bureau of Statistics, 2012, 2011b). The region contributed $9.6 billion to the NSW economy in 2011 (Australian Bureau of Statistics, 2012, 2011b).

Population and employment in the Brigalow Nandewar region are relatively stable, with a population of 176,000 in 2011 (NSW Government, 2011). Population projections expect the population will grow by 8 percent in the next 20 years to 197,700 (NSW Government, 2011). This represents an annual growth rate of 0.6 percent (NSW Government, 2011).

Unemployment rates in the region between 2002 and 2013 have been relatively stable and varied between 4.5 percent and 6.9 percent (Department of Employment, 2014). The December 2013 unemployment rate for the region was 6.9 percent.

While the Brigalow Nandewar economy depends heavily on the agriculture, forestry and fishing sector, the timber industry makes up a very small share of this sector, and consequently, the region's dependence on the timber industry is low. The timber industry only accounts for $15.7 million of value added to the region (Australian Bureau of Statistics, 2011b, 2013) and 1.2 percent of employment in the agriculture and forestry sector (or 119 full time equivalent employees, which include forestry, logging and sawmilling employees) (Australian Bureau of Statistics, 2011b, 2013).

12.6.2 Significance of other changes in the region

In contrast to active and adaptive management in State Conservation Areas, gas and mining projects are likely to result in region-wide social change through direct employment and expenditure, and the indirect or flow-on effects of additional employment and expenditure in local and regional communities. These social changes will eclipse the small changes likely to result from the implementation of active and adaptive management in the region.

Mining is becoming increasingly important in the Brigalow Nandewar region, and from 2006 – 2011 employment in this sector increased by 76 percent (Australian Bureau of Statistics, 2011a, 2006b). The Gross Regional Product of the Narrabri Local Government Area grew from $517 million in 2005-2006 to $845 million in 2010-2011, at an annual growth rate of 5.3 percent (Narrabri Shire Council, 2013).

Examples of significant potential developments in the region that may lead to cumulative and widespread social change include the Santos development of coal seam gas in the Pilliga (GHD, 2014), and the proposal for a zirconia mine near Dubbo (Western Research Institute Ltd, 2013). For example, an economic impact assessment shows the Santos project is estimated to be worth $2 billion and will employ 1,200 people in construction and 200 people during its operation (GHD, 2014).

13 Implementing active and adaptive management

Key points

KP 13.1 Ecological thinning and targeted grazing are legally permissible, so long as these activities are primarily for the purpose of achieving environmental outcomes and any commercial benefits are only a secondary outcome. Activities must also be consistent with the principles of ecological sustainable development.

Draft recommendations

The NRC recommends that:

6(b) accountability for the Adaptive Management Plan be provided through the Office of Environment and Heritage's internal accountability systems, and supported by an independent review process

6(a) current governance arrangements be revised to reduce the duplication of advisory bodies. In particular, Government should consider using the National Parks and Wildlife Regional Advisory Committees, with membership expanded to include adaptive management expertise, to provide advice during the development of the Adaptive Management Plan

6(c) a Regional Officers Working Group be established to facilitate cross-tenure operational collaboration between land managers and consider land management that is occurring on other land tenures within the Community Conservation Area

5(a) the Adaptive Management Plan for the State Conservation Areas be a legislative requirement, to be completed by the Office of Environment and Heritage within a specified time and approved by the Minister for the Environment, and include specific, measurable and spatially explicit management targets

5(b) approval of plans of management for each State Conservation Area be devolved to relevant NPWS regional managers

5(c) the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) and existing State Conservation Area plans of management be amended to expressly provide for the commercial use of residues from ecological thinning

5(d) the *Protection of Environment Operations (General) Regulation 2009* (NSW) be amended to allow the use of native forest bio-material obtained from trees cleared in accordance with the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) to be used for electricity generation

5(e) the NSW Government seek Australian Government amendments to the *Renewable Energy (Electricity) Regulations 2001* (Cth) to recognise the use of ecological thinnings residues under the Renewable Energy Target.

This chapter provides more detail around the governance arrangements and accountability mechanisms for the Adaptive Management Plan. It outlines relevant legislative requirements and approvals, including any potential legislative changes that may be required. This chapter also explains how monitoring, evaluation and reporting should drive improved performance and better management outcomes.

13.1 Revised governance, accountability and engagement arrangements

In **Section 5.4**, the NRC recommends that the Office of Environment and Heritage develop an Adaptive Management Plan for State Conservation Areas in the Brigalow and Nandewar Community Conservation Area. The Adaptive Management Plan, and the proposed consultation, collaboration and accountability mechanisms that will support it, will require revision of the current governance framework for the State Conservation Areas.

Figure 27 summarises the NRC's proposed governance arrangements to support active and adaptive management of the State Conservation Areas. The arrangements proposed are discussed in more detail throughout the remainder of this section.

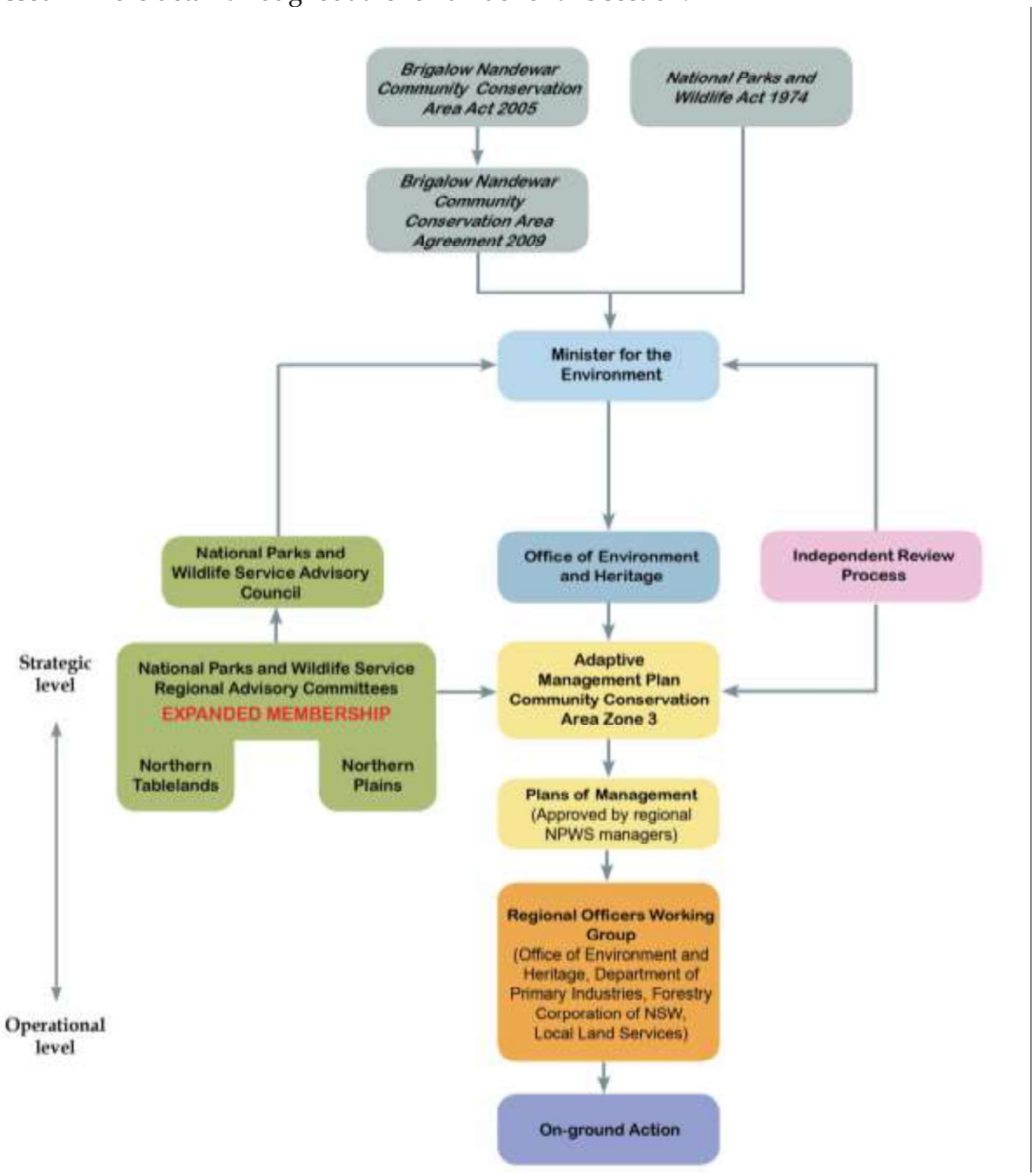


Figure 27: Proposed governance arrangements

13.1.1 Accountability mechanisms

Accountability during implementation should be provided by the Office of Environment and Heritage's internal corporate systems, as well as from an independent review process.

The NRC advises that active and adaptive management should be part of standard operating practice for the Office of Environment and Heritage and NSW National Parks and Wildlife Service. Accountability mechanisms currently in place for these organisations under the *National Parks and Wildlife Act 1974* (NSW) include the following:

- plans of management for each State Conservation Area, which are prepared by the Director General of the department administering the *National Parks and Wildlife Act 1974* (NSW) (Office of Environment and Heritage) and approved by the Minister administering the *National Parks and Wildlife Act 1974* (NSW) (the Minister for the Environment)
- stakeholder review and input to plans of management by National Parks and Wildlife Regional Advisory Committees
- state-wide National Parks and Wildlife Advisory Council that advises the Minister administering the *National Parks and Wildlife Act 1974* (NSW), including advising the Minister on approval of the State Conservation Area plans of management.

The NRC is not recommending that an external regulator such as the Environment Protection Authority is required. Regulation by the Environment Protection Authority is required for all commercial logging under the *Brigalow and Nandewar Integrated Forestry Operations Approval*. However, the NRC does not consider that the active and adaptive management, including ecological thinning, proposed within this report constitutes commercial logging under an Integrated Forestry Operations Approval, because active management interventions such as ecological thinning should only be carried out to meet specific ecological objectives within an approved plan of management. Commercial and cost-recovery opportunities are a secondary consideration once the primary ecological test has been met.

The Office of Environment and Heritage should, however, take steps to ensure that any contractors hired to undertake active management interventions are accountable for operating within specified prescriptions and guidelines, and appropriate assurance mechanisms are in place.

As an additional accountability mechanism, the development and implementation of the Adaptive Management Plan should be subject to an independent review process (see **Figure 27**). This may take the form of a review by an independent body or review panel with appropriate skills and expertise in active and adaptive management. The Minister should also seek advice from an independent reviewer before approving the plans.

13.1.2 Stakeholder engagement mechanisms

The *Brigalow and Nandewar Community Conservation Area Agreement 2009* states that the area should be managed in consultation with communities. As a result, it is important that the Adaptive Management Plan, and the plans of management for individual State Conservation Areas, are informed by consultation with community stakeholders and technical experts, particularly stakeholders with expertise in active and adaptive management.

Table 33 provides a brief overview of the advisory bodies established under the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW). Stakeholder consultation was to be facilitated through the three Community Conservation Advisory Committees.

Table 33: Advisory arrangements under the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW)

Name		Membership	Function
Community Conservation Council		Agency Director-Generals, chaired by Department of Premier and Cabinet	Responsible for developing, implementing and monitoring the *Brigalow and Nandewar Community Conservation Area Agreement 2009*.
Community Conservation Advisory Committees	*Border Rivers Gwydir*	Each committee has 15 members representing stakeholder interest groups, two members with scientific expertise and a member from the relevant National Parks and Wildlife Service Regional Advisory Committee	Responsible for advising the Community Conservation Council on the development of the *Brigalow and Nandewar Community Conservation Area Agreement 2009*. The Office of Environment and Heritage is required to seek advice from these committees on the preparation of plans of management for Zones 1–3, as well as other management plans and matters for these zones. Forestry Corporation of NSW is required to consult with these committees in the development of the Western Region Ecologically Sustainable Forest Management Plan and the application of the forest management zoning system in Zone 4.
	Central West		
	Namoi		

The NRC understands the Community Conservation Council has not met under the current NSW Government, although it remains constituted and subject to the control and direction of the Premier.

The Community Conservation Advisory Committees have not met since February 2012. A NSW Government response to a Question on Notice from 30 October 2013 indicates that the Community Conservation Advisory Committees have expired, as they have fulfilled their primary role of advising Government during the development of the *Brigalow and Nandewar Community Conservation Area Agreement 2009*.[49]

The National Parks and Wildlife Service has its own state-level Ministerial-appointed stakeholder National Parks and Wildlife Advisory Council, and two National Parks and Wildlife Service Regional Advisory Committees (Northern Tablelands and Northern Plains) in the Brigalow and Nandewar region. The Regional Advisory Committees include representatives from community groups, the local community (including neighbouring landowners), the Aboriginal community, the Rural Fire Service, education and research organisations and local councils.

The *Brigalow and Nandewar Community Conservation Area Agreement 2009* states that the National Parks and Wildlife Service Regional Advisory Committees have no function in relation to the Brigalow and Nandewar Community Conservation Area. However, in practice these groups have continued to provide advice on plans of management and perform the same legislative functions that they perform across the rest of the state.

The three Community Conservation Area Advisory Committees and two National Parks and Wildlife Service Regional Advisory Committees in the Brigalow and Nandewar region serve the

[49] NSW Government Question on Notice, 30 October 2013, Paper No. 175, *5143 Environment - Community Conservation Advisory Committee, answered 4 December 2013.

same purpose, albeit with slightly different membership and boundaries. The NRC recommends that the current governance arrangements be revised to reduce duplication of advisory bodies during the planning and implementation of the Adaptive Management Plan for the State Conservation Areas.

In particular, the NSW Government should consider using the National Parks and Wildlife Service Regional Advisory Committees to provide stakeholder input for the Adaptive Management Plan, and for plans of management as required. These Advisory Committees will need a broader skill base to perform this additional role, including expertise in adaptive management, ecological thinning, fire management and grazing for ecological outcomes.

13.1.3 Cross-tenure collaboration

The Brigalow and Nandewar Community Conservation Area was intended to support coordinated multi-use, cross-tenure land management (NSW Government, 2009). For instance, the *Brigalow and Nandewar Community Conservation Area Agreement 2009* states that land management agencies will work in partnership on common issues in Zones 1–4. As such, management of the State Conservation Areas should take into consideration land management that is occurring on other land tenures within the Community Conservation Area. This includes management on private land and in State Forests (Zone 4), as well as on National Park and Aboriginal Area tenures (Zones 1 and 2 respectively).

The Adaptive Management Plan should therefore be developed with input from the Forestry Corporation of NSW, Department of Primary Industries and Local Land Services. For instance, planners should look for opportunities to align common management actions and objectives, and identify potential areas and issues for collaborative monitoring and evaluation.

The NRC is proposing that a Regional Officers Working Group is established, as shown in the proposed governance framework in **Figure 27**. The Office of Environment and Heritage, Forestry Corporation of NSW, Department of Primary Industries and Local Land Services should use this forum to identify and facilitate opportunities for collaboration and alignment at an operational level within the Brigalow and Nandewar Community Conservation Area. For example, this would include identifying opportunities to collaborate on:

- monitoring and evaluation
- active management activities such as prescribed burns, pest and weed management
- developing commercial oportunities to improve recovery of management costs.

The structure and governance arrangements for this group would be non-prescriptive and flexibile, to capitalise on goodwill and co-operative relationships that occur at this level in the region.

13.2 Legislative requirements and proposed amendments

Implementing active and adaptive management in State Conservation Areas – including ecological thinning, targeted grazing and prescribed burning interventions – requires the Office of Environment and Heritage to meet a number of legislative requirements and potentially make some legislative amendments.

The NRC considers that active and adaptive management activities which provide commercial benefits must be approved by the Director-General under the *National Parks and Wildlife Act 1974* (NSW) as necessary for the management of State Conservation Areas.

In giving this approval, the Director-General must consider the:

- objects of the *National Parks and Wildlife Act 1974* (NSW)
- management principles for State Conservation Areas under section 30G of the *National Parks and Wildlife Act 1974* (NSW)
- provisions of relevant plans of management
- *Brigalow and Nandewar Community Conservation Area Agreement 2009*.

Legal advice indicates that ecological thinning and targeted grazing are legally permissible , so long as the Director-General is satisfied the activities are primarily for the purpose of achieving environmental outcomes, and any commercial benefits are only a secondary outcome. In making this decision the Director-General must also apply the overarching principles of ecological sustainable development.

Table 34 sets out an analysis of active and adaptive management options in State Conservation Areas against ecologically sustainable development principles.

Table 34: Analysis of active and adaptive management options in State Conservation Areas against ecologically sustainable development principles

Ecologically sustainable development principles (Adapted from Preston 2006)	Active and adaptive management in State Conservation Areas
Sustainable use: natural resources should be used in a manner that is 'sustainable', 'prudent', 'rational', 'wise' or 'appropriate'.	Active management interventions would only be applied as needed for ecological outcomes and under ecologically sound prescriptions, not as an ongoing commercial practice.
Integration: effective integration of economic and environmental considerations in the decision-making process.	Any decision to implement active management interventions would initially be based on required ecological outcomes. Consideration of possible social and economic benefits that could be derived would be a secondary decision, once the ecological need test had been met.
The precautionary principle: where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.	Once ecological objectives and requirements have been identified, adaptive management frameworks can be used to manage any associated risks surrounding the chosen intervention, and also to help progress learning and scientific certainty around management options.
Inter-generational and intra-generational equity: the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	Active and adaptive management is likely to accelerate future improvement in ecological outcomes related to forest structure, floristic diversity and faunal habitat values.

Ecologically sustainable development principles (Adapted from Preston 2006)	Active and adaptive management in State Conservation Areas
Conservation of biological diversity and ecological integrity: the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making.	Active and adaptive management is likely to accelerate future improvement in ecological outcomes related to forest structure, floristic diversity and faunal habitat values – for example, by promoting an increase in hollow-bearing and nectar-producing eucalypts.
Costs: internalisation of external environmental costs, and improved valuation, pricing and incentive mechanisms.	Commercial revenue derived from active management interventions such as ecological thinning or grazing for ecological outcomes may help pursue environmental goals in the most cost-effective way.

However, to reduce the risk of legal challenge and provide greater legal certainty around the permissibility of active and adaptive management in State Conservation Areas, the NRC recommends the NSW Government make several amendments to NSW legislation.

13.2.1 Improving legal permissibility

The NRC recommends the amendments to:

- the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) to expressly provide for the commercial use of residues from ecological thinning in State Conservation Areas, providing the primary ecological test has been met
- existing draft and final plans of management where the relevant State Conservation Area is identified as requiring active management, including permitting ecological thinning, targeted grazing and/or prescribed fire interventions (as required).

The *Protection of the Environment Operations (General) Regulation 2009* (NSW) prohibits the combustion of native forest biomaterials for electricity generation with several exemptions. In March 2014, this regulation was amended to permit the combustion of native forest biomass for electricity generation where it has been obtained:

- under a Property Vegetation Plan, including Private Native Forestry Property Vegetation Plans
- under an Integrated Forestry Operations Approval
- from a plantation
- from sawmill and wood processing waste.

However, the use of ecological thinnings residues obtained from State Conservation Areas to generate electricity remains prohibited.

The *Protection of Environment Operations (General) Regulation 2009* (NSW) should be amended to allow native forest bio-material obtained from trees cleared in accordance with the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) to be used for electricity generation.

At the national level, the Australian Government's Large Scale Renewable Energy Target program promotes renewable energy generation via renewable energy certificates. Wood waste has been an eligible renewable energy source since the scheme was put in place more than ten

years ago. However, in 2011 the definition of wood waste was changed to exclude material from native tree species.[50] The current definition of eligible wood waste includes biomass from non-native weed species but not from invasive native species, such as white cypress pine.[51] Ineligibility for renewable energy certificates makes it difficult for native forest sourced bio-energy operations to compete against other forms of renewable energy within the marketplace, including plantation based bio-energy.

It is recommended that the NSW Government seek Australian Government amendments to the *Renewable Energy (Electricity) Regulations 2001* (Cth) to recognise the use of ecological thinning residues under the Renewable Energy Target.

Additional off-grid and cogeneration opportunities within the Brigalow and Nandewar region are limited by potential customer demand, alternative biomass and fuel supplies (such a cotton waste and coal) and the capital cost of a cogeneration plant. Supplying biomass to bioenergy operations outside of the region is likely to be unfeasible given the transport costs involved.

Devolved decision-making

As discussed in **Section 13.1.1**, the *National Parks and Wildlife Act 1974* (NSW) requires plans of management for the State Conservation Areas to be prepared by the Director-General and approved by the Minister for the Environment.[52]

These requirements are administratively inefficient and do not support decision making at the local and regional scale. To promote devolved decision-making and reduce administrative complexity, the *National Parks and Wildlife Act 1974* (NSW) should be amended to allow approval of State Conservation Area plans of management to be devolved to relevant National Parks and Wildlife Service regional managers.

13.2.2 Policy and planning

Draft plans of management should be prepared for all the State Conservation Areas, with priority given to those listed in **Section 9.3**. Given the statutory processes required to prepare these plans, Statements of Interim Management Intent could be prepared in the interim to support implementation of activities in the State Conservation Areas.

The Office of Environment and Heritage and the National Parks and Wildlife Service should review existing policies and strategic plans, where relevant, to ensure they are consistent with proposed intervention options, including ecological thinning, targeted grazing and prescribed fire.

13.2.3 NSW regulatory assessments and approvals

The assessments and approvals set out in **Table 35** are currently required before active and adaptive management activities can be implemented in State Conservation Areas.

In June 2013, the NSW Government announced its intention to review the legislative framework regarding native vegetation and biodiversity, including the *Threatened Species Conservation Act 1995* (NSW), *the Native Vegetation Act 2003* (NSW), and components of the *National Parks and Wildlife Act 1974* (NSW) that relate to biodiversity. Government is also reviewing legislation regarding the protection of Aboriginal cultural heritage (NSW Office of Environment and

50 *Renewable Energy (Electricity) Amendment Regulations 2011 (No. 5)* (Cth)
51 Section 8 *Renewable Energy (Electricity) Regulations 2001* (Cth)
52 Sections 72 and 73B.

Heritage, 2014a). Statutory requirements for assessments and approvals should be confirmed before any operational activities can occur.

Table 35: Required assessments and approvals

Relevant Act	Requirement
Environmental Planning and Assessment Act 1979 (NSW)	▪ Assess likely environmental impacts of activities (refer to Part 5 of the Act). A Review of Environmental Factors was required for the ecological thinning trial in the river red gum forests of the Murray Valley National Park-Millewa Reserve Group. ▪ Consider whether an Environmental Impact Statement is required. An Environmental Impact Statement is only required if there is likely to be a significant impact on the environment (under Part 5 of the Act). For example, an Environmental Impact Statement was not required for the ecological thinning trial in the river red gum forests of the Murray Valley National Park-Millewa Reserve Group.
Fisheries Management Act 1994 (NSW)	▪ Assess likely impacts of activities on threatened fish species, populations or ecological communities. ▪ Statutory approval required if activities are likely to have significant impacts.
Heritage Act 1977 (NSW)	▪ Assess likely impacts of activities on items of historic heritage value or items which have potential historic heritage value. Steps to identify heritage items should include a search of the Office of Environment and Heritage's Historic Heritage Information Management System and the State Heritage Register. ▪ Statutory approval required if activities are likely to affect items of historic heritage value or potential heritage value.
National Parks and Wildlife Act 1974 (NSW)	▪ Ecological thinning and grazing activities must be approved by the Director-General of the Office of Environment and Heritage (see **Section 13.2** for more detail). Ecological thinning is not prohibited under the *National Parks and Wildlife Act 1974* (NSW). ▪ Exercise due diligence to determine whether activities are likely to have an impact on Aboriginal cultural heritage, for example, Aboriginal objects or Aboriginal Places (see **Section 13.2.4** for more detail). An Aboriginal Heritage Impact Permit is required if impacts are unavoidable. ▪ A lease or licence is required to authorise targeted grazing in State Conservation Areas (under Part 12 of the Act). Grazing activities need to be assessed against relevant internal Office of Environment and Heritage suitability criteria and then considered by the Minister for the Environment.
National Parks and Wildlife Regulation 2009 (NSW)	▪ Cutting and removal of vegetation from a park by Office of Environment and Heritage staff or independent contractors requires consent (refer to clause 18 of the Regulation).
Protection of Environment Operations (Waste) Regulation 2005 (NSW)	▪ Comply with tracking requirements of prescribed waste in the event of any chemical (for example fuel or hydraulic fluid) spills requiring clean-up and disposal in an appropriate landfill.

Relevant Act	Requirement
Rural Fires Act 1997 (NSW)	▪ Determine whether activities are likely to cause bushfires or increase danger of spread of bushfires on or from State Conservation Areas. ▪ Identify how activities will be carried out consistently with any fire management strategies.
Threatened Species Conservation Act 1995 (NSW)	▪ Requirements integrated with *Environmental Planning and Assessment Act 1979* (NSW). ▪ Use Assessment of Significance (*Environmental Planning and Assessment Act 1979* (NSW)) to assess likely impacts on threatened species populations, ecological communities and their habitats. ▪ Prepare a Species Impact Statement if there are likely to be significant impacts or impacts on critical habitat.

13.2.4 Determining potential impacts on Aboriginal cultural heritage

As outlined in **Table 35**, the *National Parks and Wildlife Act 1974* (NSW) requires that due diligence is exercised to determine whether activities are likely to have an impact on Aboriginal cultural heritage (for example, Aboriginal objects or Aboriginal Places).

Consideration of the potential impacts of active and adaptive management on Aboriginal cultural heritage should comply with existing agency guidelines and procedures. This includes the Office of Environment and Heritage's Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW and a search of the Office of Environment and Heritage's Aboriginal Heritage Information Management System.

Best practice indicates that the following information sources should also be used to identify Aboriginal cultural heritage values in State Conservation Areas identified as a priority for active and adaptive management (Pilliga, Pilliga West, Goonoo and Trinkey):

- consultation with local Aboriginal communities on contemporary and traditional uses of State Conservation Areas, including consultation with the Pilliga Gawambaraay Co-Management Committee and the Coonamble, Dubbo, Gilgandra, Pilliga, Walgett, Wee Waa and Walhallow Local Aboriginal Land Councils. Consultation should also occur with native title applicants (see **Table 36**)
- spatial data on landform, site density, cultural plants and other culturally sensitive information held by Local Aboriginal Land Councils within the region
- site surveys and cultural values assessments
- oral histories
- the Office of Environment and Heritage's spatial data on landforms and site distribution, including predictive modelling of landforms, site distribution and consideration of cumulative impacts (Aboriginal Sites Decision Support Tool).

13.2.5 Commonwealth statutory processes

The Commonwealth statutory processes set out in **Table 36** are currently required before active and adaptive management activities can be implemented in the State Conservation Areas.

The Commonwealth and NSW Governments are negotiating the development of bilateral agreements to establish a 'one-stop shop' for environmental impact assessments and approvals (Council of Australian Governments, 2013). Under the proposed framework, the Australian Government will accredit NSW planning systems under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) and NSW will become responsible for assessing projects for the purposes of that Act. A draft Commonwealth-NSW bilateral agreement is currently on public exhibition and applies to major project approvals and threatened species under the *Threatened Species Conservation Act 1999* (NSW) and the *Fisheries Management Act 1994* (NSW). Requirements for environmental impact assessment and approval should be confirmed before operational activities occur.

Table 36: Commonwealth statutory processes

Relevant Act	Requirement
Native Title Act 1993 (Cth)	▪ Consult with the Tubba Gah Native Title Applicant (in relation to Goonoo State Conservation Area) and the Gomeroi Native Title Applicant (in relation to all State Conservation Areas in the Brigalow and Nandewar region) regarding likely impacts on native title rights and interests.
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	▪ Determine whether species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) occur in the reserves. ▪ If required, refer proposed activities to the Commonwealth Minister for the Environment to ascertain whether they have potential to have a significant impact on Matters of National Environmental Significance (Part 3). ▪ Commonwealth assessment and approval of actions required if activities likely to have significant impacts.

13.2.6 Grazing exemptions and permissions within plans of management

Grazing is not currently legally permissible in the Leard State Conservation Area due to an express prohibition in the Leard State Conservation Area plan of management (NSW National Parks and Wildlife Service, 2012e). If targeted grazing is identified as an appropriate management intervention, the plan of management must be amended to permit targeted grazing pursuant to section 73B of the *National Parks and Wildlife Act 1974* (NSW).

13.3 Evaluating performance and driving improvement

Monitoring and research programs should collect data to answer management questions, update the assumptions underpinning process models and improve decision-making over time. Management questions should help focus monitoring and research programs on the most important knowledge gaps, define the most appropriate indicators, and reduce the risk of collecting large quantities of irrelevant or insignificant data (Lindenmeyer & Likens, 2010; Wintle et al., 2010).

Figure 28 sets out an adaptive monitoring and research framework underpinned by conceptual models and evaluation questions (adapted from Lindenmeyer & Likens 2010). The framework is based on management questions that test the assumptions underpinning the chosen management interventions. These assumptions should be described in conceptual models within the active and adaptive management plan.

The key characteristics of the framework are that:

- monitoring and research is directly related to the evaluation questions being posed (resolving traditional debates about 'what to monitor' and 'what indicator to choose')
- these questions – and thus the monitoring and research design – should evolve as managers learn and better understand the system dynamics operating in the State Conservation Areas, and as new technologies arise
- monitoring and research aims to reduce uncertainty and fill knowledge gaps – or, in other words, to answer the questions we want to answer, or to prove whether current management assumptions are right or wrong (Rumpff, 2011).

During consultation for this review, stakeholders told the NRC that targeted research is an important component of a monitoring and evaluation program to examine why a particular change has occurred (usually detected through monitoring). For example, stakeholders suggested rare and threatened species are sometimes disadvantaged by monitoring programs as they occur too sparsely (either through space or time) for the collection of reliable data. Carefully targeted scientific research can potentially resolve issues of concern, including for threatened species, over a shorter time frame.

Monitoring and research in the State Conservation Areas should complement monitoring, evaluation and reporting programs undertaken at the state scale (Natural Resources Commission, 2012).

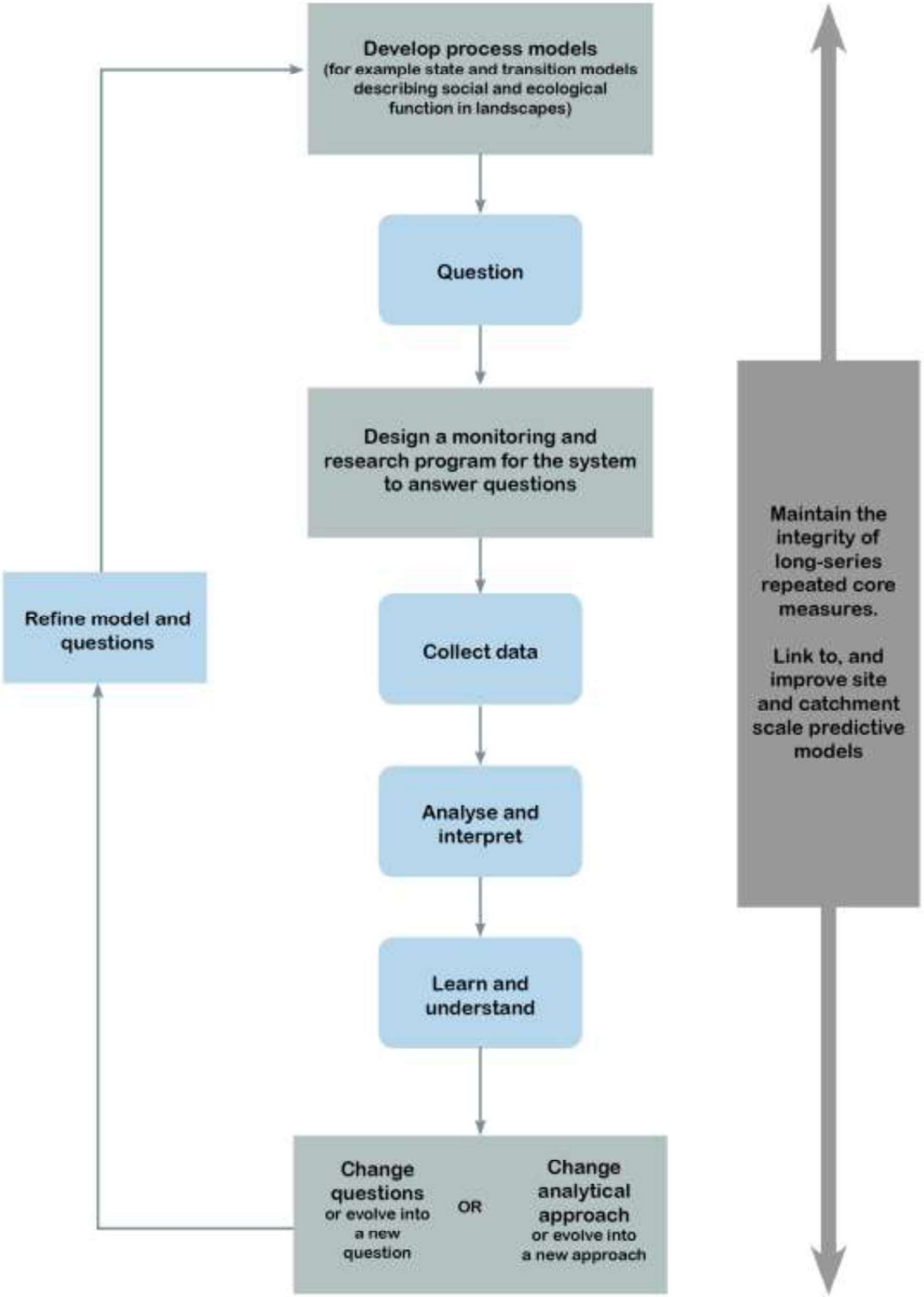


Figure 28: Adaptive monitoring and research framework (adapted from Lindenmeyer & Likens 2010)

13.3.1 Role of technology and spatial data

In this review the NRC has analysed both existing and new spatial data to explore both environmental management issues (for example, identifying extent and distribution of dense white cypress pine) and secondary economic opportunities (for example, estimating total stem volumes for dense white cypress pine stands).

Spatial data is valuable as it provides a complete census of a population, rather than the traditional approach of attempting to describe a population from samples alone. As a result, land managers now have the necessary information available to support stronger evidence-based decision-making, especially for balancing environmental and economic values. For example, spatial data can now provide more precise estimates of total stem volumes that can inform any new or revised sustainable wood supply agreements.

Technology can also play an important role in reducing the unit cost of collecting data. While spatial data can be a significant initial up-front cost over large areas (for example, LiDAR costs around $3 per hectare to capture, process and analyse), it can provide information at relatively low cost per hectare, particularly if the captured data is used multiple times and for a range of different purposes (including by multiple agencies).

Along with conceptual models, spatial data also allows managers to target field-based surveys to answer particular management questions in a cost effective way (Natural Resources Commission, 2011).

Finally, spatial analysis technology provides a good means of capturing comparable data sets over time, so that land managers are able to compare more recent spatial data with past data to identify trends within the landscape. For example, spatial analysis within this report provides an important benchmark and approach to monitoring any future change.

References

Adams, M. and Law, B. (2011) "The impact of forest thinning on bat activity: towards improved clutter-based hypotheses," In Law, B., Eby, P., Lunney, D., and Lumsden, L. (eds.), *Biology and Conservation of Australasian Bats*, Sydney, Royal Zoological Society of New South Wales, pp. 363–379.

Allen, C. and Gunderson, L. (2011) "Pathology and Failure in the Design and Implementation of Adaptive Management," *Journal of Environmental Management*, 92, pp. 1379–1380.

Allen Consulting Group (2005) *Climate change risk and vulnerability promoting an efficient adaptation response in Australia*, Canberra, Australian Greenhouse Office, Department of Environment and Heritage.

Allen, M. (1998) *Forest history projects for State Forests of New South Wales. Case studies of three cypress pine forests in the Lachlan and Bogan River catchments, Forbes Forestry District on Back Yamma, Euglo South and Strahorn State Forests*, Sydney, State Government of NSW - State Forests of NSW.

Andren, M. (2004) *Nandewar biodiversity surrogates: vertebrate fauna - Report for the Resource and Conservation Assessment Council (RACAC), NSW Western Regional Assessments, coordinated by NSW Department of Infrastructure, Planning and Natural Resources, Project no. NAND05*, Coffs Harbour, Department of Environment and Conservation.

Antos, M. and Bennett, A. (2005) "How important are temperate woodlands for ground-foraging birds?," *Wildlife Research*, 32, pp. 557–572.

Australian Bureau of Agricultural and Resource Economics and Sciences (2013) *ABARES Farm Survey 2012-2013. Selected physical and financial estimates for broadacre farms, by industry and state*, Canberra, Department of Agriculture, [online] Available from: http://www.daff.gov.au/abares/pages/surveys.aspx .

Australian Bureau of Statistics (2013) *Australian National Accounts: Input-Output Tables 2009-10 Catalogue no. 5209.0.55.001*, Canberra, Australian Bureau of Statistics.

Australian Bureau of Statistics (2012) *Australian National Accounts: National Income, Expenditure and Product - cat. no. 5206.0.*, Canberra, Australian Bureau of Statistics, [online] Available from: abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/F11665D07974DA4BCA257B8000130BC0?opendocument.

Australian Bureau of Statistics (2011a) *Basic Community Profile Catalogue 2001.0*, Canberra, RA12, LGA12600, LGA12950, LGA13550, LGA13660, LGA14200, LGA14920, LGA15300, LGA17310, LGA17400, LGA17620, LGA18020, SSC11934, UCL112012, SSC11678, SSC11054, SSC11050, SSC10735, SSC10603, SSC10218, SSC10109.

Australian Bureau of Statistics (2006a) *Basic Community Profile Catalogue 2001.0*, Canberra, (RA12; LGA12600; LGA12950; LGA13550; LGA13660; LGA14200; LGA14920; LGA15300; LGA17310; LGA17400; LGA17620; LGA18020; SSC16157; SSC16291; SSC16809; SSC17007; SSC17437; SSC17449; SSC18295; SSC18595; UCL172000.

Australian Bureau of Statistics (2001) *Basic Community Profile Catalogue 2001.0*, Canberra, (RA12, LGA12600; LGA12950; LGA13550; LGA13660; LGA14200; LGA14920; LGA15300; LGA17310; LGA17400; LGA17620; LGA18020; UCL103800; UCL109200; UCL121400; UCL127800; UCL136800; UCL159200; UCL166600; UCL172000.

Australian Bureau of Statistics (2011b) *Census of Population and Housing.*, Canberra, Based on Place of Work. Retrieved using TableBuilder Pro, Australian Bureau of Statistics.

Australian Bureau of Statistics (2006b) *Time Series Profile, Catalogue 2003.0*, Canberra, RA12, LGA12600, LGA12950, LGA13550, LGA13660, LGA14200, LGA14920, LGA15300, LGA17310, LGA17400, LGA17620, LGA18020.

Australian Government Department of the Environment (2013a) "Australian Government Biodiversity Hotspots," [online] Available from: http://www.environment.gov.au/topics/biodiversity/biodiversity-conservation/biodiversity-hotspots/national-biodiversity-hotspots#hotspot2 (Accessed 28 March 2014).

Australian Government Department of the Environment (2013b) "Environment Protection and Biodiversity Conservation Act 1999 Protected Matters Reports," [online] Available from: environment.gov.au/epbc/pmst/ (Accessed 19 December 2013).

Australian Government Department of the Environment (2013c) "Leipoa ocellata - Malleefowl - Species Profile and Threats Database," [online] Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=934 (Accessed 17 April 2014).

Australian Government Department of the Environment (2007) *Maintaining Australia's Biodiversity Hotspots – Programme Guidelines*, Canberra.

Ayers, D., Melville, G., Bean, J., Beckers, D., Ellis, M., Mazzer, T. and Freudenberger, D. (2001) *Woody Weeds, Biodiversity and Landscape Function in Western NSW*, Dubbo, WEST 2000.

Baalman, E. (2003) *Strategic inventory - Nandewar Bioregion, NSW Western Regional Assessments, Project Number: NAND 08*, Sydney, Resource and Conservation Assessment Council.

Balvanera, P., Pfisterer, A., Buchmann, N., He, J., Nakashizuka, T., Raffaelli, D. and Schmid, B. (2006) "Quantifying the evidence for biodiversity effects on ecosystem functioning and services," *Ecology Letters*, 9, pp. 1146–1156.

Barnes, P. and Archer, S. (1999) "Tree-shrub interactions in a subtropical savannah parkland: competition or facilitation?," *Journal of Vegetation Science*, 10(4), pp. 525–536.

Belsky, A. and Blumenthal, D. (1997) "Effects of livestock grazing on stand dynamics and soils in upland forests of the Interior West," *Conservation biology: the journal of the Society for Conservation Biology*, 11(2), pp. 315–327.

Bennett, A. F. (2003a) "Habitat fragmentation," In Attiwill, P. and Wilson, B. (eds.), *Ecology: an Australian perspective*, South Melbourne, Oxford University Press, pp. 440–455.

Bennett, A. F. (2003b) *Linkages in the landscape: the role of corridors and connectivity in wildlife conservation*, Gland, Switzerland and Cambridge, UK, IUCN, [online] Available from: http://data.iucn.org/dbtw-wpd/edocs/FR-021.pdf.

Benson, J. (1999) *Setting the scene: the native vegetation of New South Wales - Background Paper No. 1*, Sydney, Native Vegetation Advisory Council of NSW.

Berney, P. (2013) *Cypress pine population dynamics and management options in response to dense Cypress regrowth in the Northern Plains Region*, Narrabri, internal report prepared by Peter Berney, Regional Ecologist – Northern Plains Region, New South Wales National Parks and Wildlife Service.

Binns, D. and Beckers, D. (2001) "Floristic Patterns in the Pilliga," In Dargavel, J., Hart, D., and Libbis, B. (eds.), *Perfumed Pineries: Environmental History of Australia's Callitris forests*, Canberra, Centre for Resource and Environmental Studies, Australian National University, pp. 104–110.

Boudon, R. (1986) *Theories of social change*, Oxford, Polity Press.

Bowen, M. E., McAlpine, C. A., Seabrook, L. M., House, A. P. N. and Smith, G. C. (2009) "The age and amount of regrowth forest in fragmented brigalow landscapes are both important for woodland dependent birds," *Biological Conservation*, 142, pp. 3051–3059.

Bowman, D. and Latz, P. (1993) "Ecology of Callitris glaucophylla (Cupressaceae) on the MacDonnell Ranges, Central Australia," *Australian Journal of Botany*, 41, pp. 217–225.

Briggs, S. and Tooth, I. (1994) "Terrestrial birds in uncropped and cropped lakebeds in surrounding woodlands," In Briggs, S. (ed.), *Ecological management of lakebed cropping: report to Environmental Trusts*, Canberra, National Parks and Wildlife Service and CSIRO Wildlife and Ecology.

Bustard, H. (1968) "The ecology of the Australian gecko Heteronotia binoei in northern New South Wales," *Journal of Zoology*, 156(48), pp. 483–497.

Butler, C. and Oluoch-Kosura, W. (2006) "Linking future ecosystem services and future human well-being," *Ecology and Society*, 11(1), p. 30.

Callaway, R. and Walker, L. (1997) "Competition and facilitation: a synthetic approach to interactions in plant communities," *Ecology*, 78(7), pp. 1958–1965.

Cameron, M. (2006) "Nesting habitat of the glossy black cockatoo in central NSW," *Biological Conservation*, 127(4), pp. 402–410.

Cameron, P. (2003) *Actively managing for Biodiversity - some observations of the benefits of thinning cypress stands and discussion of management options for western forests and woodlands*, Dubbo, A report to the Western Plains Zoo.

Central West Catchment Management Authority (2011) *Catchment Action Plan 2011-2021*, Dubbo.

Chapin III, F., Kofinas, G., Folke, C., Carpenter, S., Olsson, P., Abel, N., Biggs, R., Naylor, R., Pinkerton, E., Stafford Smith, D., Steffen, W., Walker, B. and Young, O. (2009) "Resilience-

Based Stewardship: Strategies for Navigating Sustainable Pathways in a Changing World," In Chapin III, F., Kofinas, G., and Folke, C. (eds.), *Principles of Ecosystem Stewardship – Resilience-Based Natural Resource Management in a Changing World*, New York, Springer Science and Business Media, pp. 319–337.

Cohn, J., Lunt, I., Bradstock, R. and Koen, T. (2012) "Interactions between dense Callitris regeneration and Eucalyptus and Callitris canopy trees in semiarid woodlands," *Australian Journal of Botany*, 60, pp. 549–558.

Commonwealth of Australia (2009) *Australia's Strategy for the National Reserve System 2009-2030*, Canberra, Australian Government.

Costanza, R., D'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P. and van den Belt, M. (1997) "The value of the world's ecosystem services and natural capital," *Nature*, 387, pp. 253–260.

Council of Australian Governments (2013) *Council of Australian Governments Communique 13 December 2013*, Canberra, Council of Australian Governments, [online] Available from: https://www.coag.gov.au/node/516.

Craig, R. and Ruhl, J. (2014) "Designing Administrative Law for Adaptive Management," *Vanderbilt Law Review*, 67(1), pp. 1–86.

CSIRO (2014) "Light detection and ranging (lidar)," [online] Available from: http://www.csiro.au/Outcomes/Food-and-Agriculture/LightDetectionLidar.aspx (Accessed 19 May 2014).

Cunningham, S. C., Baker, P. and Horner, G. J. (2009) *Proposed ecological thinning trials for River Red Gum forests in the middle Murray River floodplain in Victoria*, Melbourne, Australian Centre for Biodiversity, School of Biological Sciences, Monash University.

Curby, P. and Humphries, A. (2002) *Non-Indigenous Cultural Heritage Study, NSW Western Regional Assessments Brigalow Belt South Stage 2*, Sydney, Resource and Conservation Assessment Council.

CWCMA and WCMA (2010) *Managing invasive native scrub to rehabilitate native pastures and open woodlands – a best management practice guide to the central west and western catchments*, Wellington and Cobar, Central West Catchment Management Authority and Western Catchment Management Authority.

Daly, R. and Hodgkinson, K. (1996) "Relationships between grass, shrub and tree cover on four landforms of semi-arid eastern Australia, and prospects for change by burning," *Rangelands Journal*, 18(1), pp. 104–117.

Dangerfield, J. M. and Pik, A. J. (2001) *Biological width of ephemeral streams*, Sydney, Key Centre for Biodioversity & Bioresources, Macquarie University.

Date, E., Ford, H. and Recher, H. (2002) "Impacts of logging, fire and grazing regimes on bird species assemblages of the Pilliga Woodlands of New South Wales," *Pacific Conservation Biology*, 8, pp. 177–179.

Date, E., Goldney, D., Bauer, J. and Paull, D. (2000) "The status of threatened vertebrate fauna in New South Wales cypress woodlands: implications for state forest management," In Craig, J., Mitchell, N., and Saunders, D. (eds.), *Nature conservation 5: nature conservation in production environments: managing the matrix*, Sydney, Surrey, Beatty and Sons, pp. 128–145.

Department of Employment (2014) *Data tables – Small area labour markets – December quarter 2013*, [online] Available from: http://employment.gov.au/small-area-labour-markets-publication.

Department of Primary Industries (2009) *Barking Owls - barking up the right tree in the Pilliga forests*, Sydney, Department of Primary Industies, State Government of New South Wales.

Department of Prime Minister and Cabinet (2014) "Review of the Renewable Energy Target,".

Drielsma, M. J., Howling, G. and Love, J. (2012) *NSW Native Vegetation Management Analyses:Technical report.*, Sydney, NSW Office of Environment and Heritage.

Duckett, P. E. and Stow, A. J. (2011) "Levels of dispersal and tail loss in an Australian gecko (Gehyra variegata) are associated with differences in forest structure," *Australian Journal of Zoology*, 59(3), pp. 170–176, [online] Available from: http://www.publish.csiro.au/?paper=ZO11055.

Duncan, D. and Wintle, B. (2008) "Towards Adaptive Management of Native Vegetation in Regional Landscapes," In Pettit, C., Cartwright, W., Bishop, I., Lowell, K., Puller, D., and Duncan, D. (eds.), *Landscape Analysis and Visualisation: Spatial Models for Natural Resource Management and Planning*, Berlin, Springer Verlag, pp. 159–182.

Eco Logical Australia (2014) *Mapping White Cypress Pine Callitris glaucophylla with ADS40 imagery - A field validation to determine product accuracy and reliability - a technical paper commissioned by the Natural Resources Commission*.

Eldridge, D., Bowker, M., Maestre, F., Roger, E., Reynolds, J. and Whitford, W. (2011) "Impacts of shrub encroachment on ecosystem structure and functioning: towards a global synthesis," *Ecology letters*, 14(7), pp. 709–722.

Eyre, T. J., Maron, M., Mathieson, M. T. and Haseler, M. (2009) "Impacts of grazing, selective logging and hyper-aggressors on diurnal bird fauna in intact forest landscapes of the Brigalow Belt, Queensland.," *Austral Ecology*, 34, pp. 705–716.

Flannery, T. (1994) *The Future Eaters*, Melbourne, Reed Books.

Ford, H., Walters, J., Cooper, C., Debus, S. and Doerr, V. (2009) "Extinction debt or habitat change? – Ongoing losses of woodland birds in north-eastern New South Wales, Australia," *Biological Conservation*, 142(12), pp. 3182–3190.

Forestry Corporation of NSW (2013) *Image Analysis for Identification of White Cypress*, Sydney, Internal report prepared by Forest Information and Planning, Forestry Corporation of NSW.

Forestry Corporation of NSW (1989) *Research Note No. 17 - Forest types in New South Wales*, Sydney, Forestry Corporation of NSW.

Forestry Corporation of NSW (2014) *White Cypress Volume Predictions using LiDAR Derived Heights for Pilliga and Gunnedah Management Areas - March 2014*, Sydney, Internal report prepared by Forest Information and Planning, Forestry Corporation of NSW.

Forests NSW (2008) *Forests NSW Ecologically Sustainable Forest Management Plan – Western Region NSW*, Beecroft, NSW Department of Primary Industries.

Franklin, J. F. (2003) "Challenges to temperate forest stewardship - focusing on the future," In Lindenmayer, D. and Franklin, J. (eds.), *Towards forest sustainability*, Collingwood, Victoria, CSIRO Publishing, pp. 1–13.

Freudenberger, D. and Brooker, L. (2004) "Development of a focal species approach for biodiversity conservation in the temperate agricultural zones of Australia," *Biodiversity and Conservation*, 12, pp. 253–274.

Gallopin, G. C. (2006) "Linkages between vulnerability, resilience and adaptive capacity," *Global Environmental Change*, 16, pp. 293–303.

Gammage, B. (2011) *The Biggest Estate on Earth: how Aborigines Made Australia*, Sydney, Allen and Unwin.

GHD (2014) *Santos NSW (Eastern) Pty Ltd Narrabri Gas Project Preliminary Environmental Assessment March 2014*, Sydney, GHD.

Gibbons, P. and Lindenmayer, D. (2002) *Tree hollows and wildlife conservation in Australia*, Collingwood, CSIRO Publishing.

Gill, M. (1981) "Adaptive responses of Australian vascular plant species to fire," In Gill, A. M., Groves, R., and Noble, I. (eds.), *Fire and the Australian Biota*, Canberra, Australian Academy of Science.

Gunnedah Timbers Pty Ltd (2012) *Inquiry into management of public land in New South Wales Submission No 289*, [online] Available from: http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/0/768c5db08d489ab2ca257a7800029fd5/$FILE/0289 Gunnedah Timbers Pty Ltd.pdf.

Haines-Young, R., Potschin, M. and Cheshire, D. (2006) *Defining and Identifying Environmental Limits for Sustainable Development - Final Report - Defra Project Code NR0102*, London, UK Department for Environment, Food and Rural Affairs.

Hart, D. (1995) "Litterfall and decomposition in the Pilliga State Forests, New South Wales, Australia," *Australian Journal of Ecology*, 20, pp. 266–272.

Hassall & Associates Pty Ltd (2004) *Nandewar Bioregion Economic and Social Regional Profile*, Sydney, Department of Planning, Infrastructure and Natural Resources.

Hastings, R. and Beattie, A. (2006) "Stop the bullying in the corridors: Can including shrubs make your revegetation more noisy miner free?," *Ecological Management & Restoration*, 7, pp. 105–112.

Helzer, C. and Jelinski, D. (1999) "The Relative Importance of Patch Area and Perimeter-Area Ratio to Grassland Breeding Birds," *Ecological Applications*, 9(4), pp. 1448 – 1458, [online] Available from: http://www.jstor.org/stable/2641409?origin=crossref.

Hobbs, R. (1999) *Restoring the Health and Wealth of Ecosystems*, Perth, CSIRO.

Hobbs, R., Hallett, L., Ehrlich, P. and Mooney, H. (2011) "Intervention ecology: applying ecological science in the twenty-first century," *BioScience*, 61, pp. 442–450.

Hollings, C. (1978) *Adaptive Environmental Assessment and Management*, London, Wiley.

Horne, R. (1990) "Early escapement of wheatfield white cypress pine regeneration: the effect on secondary regeneration, limb size, and stand merchantability," *Australian Forestry*, 53, pp. 160–167.

Horne, R. and Robinson, G. (1987) "White cypress pine in NSW: growth patterns and optimal thinning regimes for 60- to 80- year-old stands," *Australian Forestry*, 50(4), pp. 216–223.

Horner, G., Baker, P., Mac Nally, R., Cunningham, S., Thomson, J. and Hamilton, F. (2010) "Forest structure, habitat and carbon benefits from thinning floodplain forests: Managing early stand density makes a difference," *Forest Ecology and Management*, 259, pp. 286–293.

Horner, G., Baker, P., Mac Nally, R., Cunningham, S., Thomson, J. and Hamilton, F. (2009) "Mortality of developing floodplain forests subjected to a drying climate and water extraction," *Global Change Biology*, 15, pp. 2176–2186.

Hunter, J. (2013) "Interactions between Callitris above-ground biomass, species density and plant form in north-eastern New South Wales," *Australian Journal of Botany*, 61(1), pp. 73–79.

Hunter, J. T. (2008a) *Vegetation and Floristics of Biddon State Conservation Reserves*, Narrabri, Unpublished report to the New South Wales National Parks and Wildlife Service.

Hunter, J. T. (2008b) *Vegetation and Floristics of Bobbiwaa State Conservation Reserves*, Narrabri, Unpublished report to the New South Wales National Parks and Wildlife Service.

Hunter, J. T. (2010) *Vegetation and Floristics of Cubbo, Etoo and Dewsons Lease sections of the Pilliga State Conservation Area, Pilliga National Park and Pilliga West State Conservation Area*, Narrabri, Unpublished report to the New South Wales National Parks and Wildlife Service.

Hunter, J. T. (2008c) *Vegetation and Floristics of Trinkey State Conservation Reserves*, Narrabri, Unpublished report to the New South Wales National Parks and Wildlife Service.

James, C. D. (2003) "Response of vertebrates to fenceline contrasts in grazing intensity in semi-arid woodlands of eastern Australia," *Austral Ecology*, 28, pp. 137–151.

Jurskis, V. (2011) "Benchmarks of fallen timber and man's role in nature: some evidence from eucalypt woodlands in southeastern Australia," *Forest Ecology and Management*, 261(11), pp. 2149–2156.

Jurskis, V. (2009) "River red gum and white cypress forests in south-western New South Wales, Australia: Ecological history and implications for conservation of grassy woodlands," *Forest Ecology and Management*, 258(11), pp. 2593–2601.

Kavanagh, R. and Barrott, E. (2001) "Koala populations in the Pilliga Forests," In Dargavel, J., Hart, D., and Libbis, B. (eds.), *Perfumed Pineries: Environmental history of Australia's Callitris forests*, Canberra, Centre for Resource and Environmental Studies, Australian National University, pp. 93–103.

Kavanagh, R., Stanton, M. and Brassil, T. (2007) "Koalas continue to occupy their previous home ranges after selective logging in Callitris-Eucalyptus forest," *Wildlife Research*, 34, pp. 94–107.

Keith, D. (2004) *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*, Hurstville, Department of Enviornment and Conservation.

Keith, D., Martin, T., McDonald-Madden, E. and Walters, C. (2011) "Uncertainty and adaptive management for biodiversity conservation," *Biological Conservation*, 144(4), pp. 1175–1178.

Kerle, J. A. (2005) *Collation and review of stem density data and thinning prescriptions for the vegetation communities of New South Wales*, Sydney, report prepared for Department of Environment and Conservation (NSW), Policy and Science Division.

Killey, P., McElhinny, C., Rayner, I. and Woods, J. (2010) "Modelling fallen branch volumes in a temperate eucalypt woodland: implications for large senescent trees and benchmark loads of coarse woody debris," *Australian Ecology*, 35(8), pp. 956–968.

Kingsford, R. and Biggs, H. (2012) *Strategic adaptive management guidelines for effective conservation of freshwater ecosystems in and around protected areas of the world*, Sydney, IUCN WCPA Freshwater Taskforce, Australian Wetlands and Rivers Centre.

Kirby, K. (1992) "Accumulation of deadwood – a missing ingredient in coppicing?," In Buckley, G. (ed.), *Ecology and Management of Coppice Woodlands*, Melbourne, Chapman and Hall.

Knott, J. (1995) *White Cypress Pine thinning trials of the Western Region*, Sydney, State Government of NSW - State Forests of NSW.

Lacey, C. (1972) *Factors influencing occurrence of cypress pine regeneration in NSW - Technical paper No. 21*, Sydney, State Forests of NSW, State Government of NSW.

Lacey, C. (1973) *Silvicultural characteristics of white cypress pine - Research Note 26*, Sydney, Forestry Commission of NSW, State Government of NSW.

Lachappelle, P., McCool, S. and Patterson, M. (2003) "Barriers to Effective Natural Resource Planning in a '"Messy"' World," *Society and Natural Resources*, 16, pp. 473–490.

Lambeck, R. and Saunders, D. (1993) "The role of patchiness in reconstructed wheatbelt land-scapes," In Saunders, D., Hobbs, R., and Ehrlich, P. (eds.), *Nature Conservation 3: Reconstruction of Fragmented Ecosystems*, Sydney, Surrey, Beatty and Sons, pp. 153–161.

Law, B., Chidel, M. and Tap, P. (2011) "Bat activity in ephemeral stream-beds in the Pilliga forests: clarifying the importance of flyways and buffer widths in open forest and

woodland," In Law, B., Eby, P., Lunney, D., and Lumsden, L. (eds.), *Biology and Conservation of Australasian Bats*, Sydney, Royal Zoological Society of New South Wales, pp. 308–321.

Law, B. and Dickman, C. (1997) "The use of habitat mosaics by terrestrial vertebrate fauna: implications for conservation and management," *Biodiversity and Conservation*, 7, pp. 323–333.

Lewis, S. (1995) "Roost fidelity of bats: a review," *Journal of Mammalogy*, 76(2), pp. 481–496.

Lindenmayer, D. B. and Fischer, J. (2006) *Habitat fragmentation and landscape change: an ecological and conservation synthesis*, Collingwood, CSIRO Publishing.

Lindenmayer, D. and Franklin, J. (2002) *Conserving Forest Biodiversity: A comprehensive multi-scaled approach*, Washington, Island Press.

Lindenmayer, D., Franklin, J. and Fischer, J. (2006) "General management principles and a checklist of strategies to guide forest biodiversity conservation," *Biological Conservation*, 131, pp. 433–445.

Lindenmeyer, D. and Likens, G. (2010) *Effective Ecological Monitoring*, Collingwood, CSIRO Publishing.

Lindsay, A. (1967) *Forest Types of New South Wales Cypress Pine Zone: Technical Paper 8*, Sydney, Forestry Commission of NSW, State Government of NSW.

Lindsay, A. (1946) *Pilliga management survey: instructions for forest estimators (unpublished)*, Sydney, Forestry Commission of NSW, State Government of NSW.

Lunt, I., Eldridge, D., Morgan, J. and GB, W. (2007) "Turner Review No. 13: A framework to predict the effects of livestock grazing and grazing exclusion on conservation values in natural ecosystems in Australia," *Australian Journal of Botany*, 55(4), pp. 401–15.

Lunt, I., Jones, N., Spooner, P. and Petrow, M. (2006) "Effects of European colonization on indigenous ecosystems: post-settlement changes in tree stand structures in Eucalyptus-Callitris woodlands in central New South Wales, Australia," *Journal of Biogeography*, 33(6), pp. 1102–1115.

Lunt, I., Zimmer, H. and Cheal, D. (2011) "The tortoise and the hare? Post-fire regeneration in mixed Eucalyptus-Callitris forest," *Australian Journal of Botany*, 59(6), pp. 575–581.

MacHunter, J., Wright, W., Loyn, R. and Rayment, P. (2006) "Bird declines over 22 years in forest remnants in southeastern Australia: Evidence of faunal relaxation?," *Canadian Journal of Forest Research*, 36(11), pp. 2756–2768.

MacNally, R. and Horrocks, G. (2008) "Longer-term responses of a floodplain-dwelling marsupial to experimental manipulation of fallen timber loads," *Basic and Applied Ecology*, 9, pp. 456–465.

MacNally, R. and MacGoldrick, J. (1997) "Landscape dynamics of bird communities in relation to mass flowering in some eucalypt forests of central Victoria, Australia," *Journal of Avian Biology*, 28, pp. 171–183.

Maguire, O., Armstrong, R. C., Benson, J. S., Streeter, R., Paterson, C., McDonald, P., Salter, N., East, M., Webster, M., Sheahan, M. and Young, D. (2012) "Using high resolution digital aerial imagery interpreted in a 3-D digital GIS environment to map predefined plant communities in central-southern New South Wales," *Cunninghamia*, 12(4), pp. 247–266.

Maher, M. (1995) *A Thin Line: Should densities of coolibah and black box be controlled in the Western Division of New South Wales?*, Dubbo, Western Lands Commission.

Maron, M. and Kennedy, S. (2007) "Roads, fire and aggressive competitors: determinants of bird distribution in subtropical production forests," *Forest Ecology and Management*, 240(1), pp. 24–31.

Maron, M. and Lill, A. (2005) "The influence of livestock grazing and weed invasion on habitat use by birds in grassy woodland remnants.," *Biological Conservation*, 124, pp. 439–450.

Martin, T. G., Kuhnert, P. M., Mengersen, K. and Possingham, H. P. (2005) "The power of expert opinion in ecological models using Bayesian methods: impact of grazing on birds," *Ecological Applications*, 12, pp. 266–280.

Martin, T. G. and Possingham, H. P. (2005) "Predicting the impact of livestock grazing on birds using foraging height data," *Journal of Applied Ecology*, 42, pp. 400–408.

McAlpine, C., Seabrook, L., Morrison, T. and Rhodes, J. (2013) "Strengthening Landscape Ecology's Contribution to a Sustainable Environment," In Fu, B. and Jones, K. (eds.), *Landscape Ecology for Sustainable Environment and Culture*, Dordrecht, Springer Science and Business Media, pp. 21–35.

McHenry, M., Wilson, B., Lemon, J., Donnelly, D. and Growns, I. (2006) "Soil and vegetation response to thinning White Cypress Pine (Callitris glaucophylla) on the North Western Slopes of New South Wales, Australia," *Plant and Soil*, 285(1-2), pp. 245–255.

McIntyre, S. and Barrett, G. (1992) "Habitat variegation, an alternative to fragmentation," *Conservation biology: the journal of the Society for Conservation Biology*, 6(1), pp. 146–147.

McLain, R. and Lee, R. (1996) "Adaptive management: Promises and pitfalls," *Environmental management*, 20(4), pp. 437–448.

Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being - Synthesis*, Washington, DC, Island Press.

Moseby, K., Neilly, H., Read, J. and Crisp, H. (2012) "Interactions between a top order predator and exotic mesopredators in the Australian rangelands," *International Journal of Ecology*, 2012.

Narrabri Shire Council (2007) *Assessment of Opportunities for Narrabri Shire from Coal Mining and Gas Extraction in the Gunnedah Basin*, Adopted by Council – 19 June 2007 (403/2007), [online] Available from: narrabri.nsw.gov.au/files/uploaded/file/Economic Development PDFs/Narrabri Coal Adopted report.pdf .

Narrabri Shire Council (2013) *Narrabri Shire Community Strategic Plan...towards 2023*, Narrabri, Narrabri Shire Council.

Narrabri Shire Council (2009) *Narrabri Shire Growth Management Strategy*, [online] Available from: narrabri.nsw.gov.au/files/uploaded/file/Planning and Development/Growth Management Strategy/Growth Management Strategy Final 1_3.pdf .

Natural Resources Commission (2010a) *Progress towards healthy resilient landscapes – implementing the standard, targets and catchment action plans*, Sydney, Natural Resources Commission.

Natural Resources Commission (2010b) *Regional Forest Assessment: South-western Cypress State Forests*, Sydney, Natural Resources Commission.

Natural Resources Commission (2011) *Review of NSW Resource condition monitoring, evaluation and reporting - continuing the evolution of monitoring, reporting and evaluation in NSW - Draft Report*, Sydney, Natural Resources Commission, [online] Available from: http://www.nrc.nsw.gov.au/content/documents/MER - Draft report 2011.pdf.

Natural Resources Commission (2012) *Review of NSW resource condition monitoring, evaluation and reporting - Final Report*, Sydney, Natural Resources Commission.

Natural Resources Commission (2009) *Riverina Bioregion Regional Forest Assessment: River Red Gums and Woodland Forests*, Sydney, Natural Resources Commission.

Nelson, D. R., Adger, W. N. and Brown, K. (2007) "Adaptation to environmental change: contribution of a resilience framework," *Annual Review of Environment and Resources*, 32, pp. 395–419.

Nicholson, D. (1997) *Managing cypress pine on your property*, Dubbo, State Forests of NSW, Western Division.

Nicholson, E. and Possingham, H. (2006) "Objectives for Multiple-Species Conservation Planning," *Conservation biology: the journal of the Society for Conservation Biology*, 20(3), pp. 871–881.

Noble, J. (1993) *The Delicate and Noxious Scrub - CSIRO Studies on Native Tree and Shrub Proliferation in the Semi-Arid Woodlands of Eastern Australia*, Canberra, CSIRO.

Norris, E., Mitchell, P. and Hart, D. (1991) "Vegetation changes in the Pilliga forests: A preliminary evaluation of the evidence," *Vegetatio*, 91(1-2), pp. 209–218.

Noss, R. (1990) "Indicators for Monitoring Biodiversity: A Hierarchical Approach," *Conservation biology: the journal of the Society for Conservation Biology*, 4(4), pp. 355–364.

NSW Aboriginal Affairs (2013) *OCHRE Opportunity, Choice, Healing, Responsibility, Empowerment*, NSW Aboriginal Affairs, [online] Available from: http://www.aboriginalaffairs.nsw.gov.au/wp-content/uploads/2013/04/AA_OCHRE_final.pdf.

NSW Apiarists' Association Inc. (2013) *Submission to Natural Resources Commission review*, Submission to Natural Resources Commission review by NSW Apiarists' Association Inc.

NSW Chief Scientist & Engineer (2013) *Initial report on the Independent Review of Coal Seam Gas Activities in NSW*, Sydney, NSW Chief Scientist & Engineer.

NSW Department of Mineral Resources (2000) *Assessment of Hydrocarbon Potential: Southern Brigalow Bioregion, Pilliga, New South Wales*, Sydney, Report prepared for NSW Department of Mineral Resources by Upstream Petroleum Consulting Services.

NSW Department of Mineral Resources (2002) *Mineral and Petroleum Resources and Potential - Project Number WRA/20*, Sydney, A project undertaken for the Resource and Conservation Assessment Council NSW Western Regional Assessments.

NSW Department of Trade and Investment (2013) "MinView 2," [online] Available from: minview.minerals.nsw.gov.au/mv2web/mv2 (Accessed 22 November 2013).

NSW Government (2009) *Brigalow and Nandewar Community Conservation Area Agreement*, Sydney, NSW Government.

NSW Government (2014a) *Draft Ministerial Order for Clearing of Invasive Native Species*, Sydney, NSW Government.

NSW Government (2014b) *Draft Ministerial Order for Thinning of Native Vegetation*, Sydney, NSW Government.

NSW Government (2010) *Integrated Forestry Operations Approval for the Brigalow and Nandewar Region*, Sydney, NSW Government.

NSW Government (2011) "Population and housing projections," [online] Available from: http://www.planning.nsw.gov.au/en-au/deliveringhomes/populationandhousingprojections.aspx (Accessed 24 April 2014).

NSW Government (2007) *Private Native Forestry Code of Practice for Cypress and Western Hardwood Forests*, Sydney, Environmental Protection Authority, NSW Government.

NSW Government (2013) *Report no. 37 - Management of public land in New South Wales*, Sydney, NSW Parliament Legislative Council General Purpose Standing Committee No. 5.

NSW National Parks and Wildlife Service (2002a) *Aboriginal Cultural Heritage Assessment – NSW Western Regional Assessments, Brigalow Belt South Bioregion Stage 2*, Sydney, Resource and Conservation Assessment Council.

NSW National Parks and Wildlife Service (2002b) *Bee Keeping Policy*, Sydney, NSW Office of Environment and Heritage.

NSW National Parks and Wildlife Service (2013) *Biddon State Conservation Area Fire Management Strategy 2013-18*, Sydney, NSW Office of Environment and Heritage.

NSW National Parks and Wildlife Service (2012a) *Draft Plan of Management - Trinkey State Conservation Area - Trinkey Community Conservation Area Zone 3*, Narrabri, NSW Office of Environment and Heritage.

NSW National Parks and Wildlife Service (2012b) *Draft Plan of Management - Wondoba State Conservation Area - Wondoba Community Conservation Area Zone 3*, Narrabri, NSW Office of Environment and Heritage.

NSW National Parks and Wildlife Service (2014) "Pilliga National Park," [online] Available from: http://www.nationalparks.nsw.gov.au/pilliga-national-park (Accessed 28 April 2014).

NSW National Parks and Wildlife Service (2012c) *Plan of Management - Biddon State Conservation Area - Biddon Community Conservation Area Zone 3*, Narrabri, NSW Office of Environment and Heritage.

NSW National Parks and Wildlife Service (2012d) *Plan of Management - Bullawa Creek State Conservation Area - Bullawa Creek Community Conservation Area Zone 3*, Narrabri, NSW Office of Environment and Heritage.

NSW National Parks and Wildlife Service (2012e) *Plan of Management - Leard State Conservation Area - Leard Community Conservation Area Zone 3*, Narrabri, NSW National Parks and Wildlife Service.

NSW National Parks and Wildlife Service (2009) *Trinkey State Conservation Area - Cultural Heritage Survey May 2009*, Baradine, Unpublished report to National Parks and Wildlife Service.

NSW Office of Environment and Heritage (2014a) "Aboriginal cultural heritage reform," [online] Available from: http://www.environment.nsw.gov.au/achreform/ (Accessed 29 April 2014).

NSW Office of Environment and Heritage (2013a) "Aboriginal Heritage Information Management System (AHIMS)," Sydney, NSW Office of Environment and Heritage, [online] Available from: http://www.environment.nsw.gov.au/licences/AboriginalHeritageInformationManagementSystem.htm.

NSW Office of Environment and Heritage (2013b) "BioNet – Atlas of NSW Wildlife," [online] Available from: bionet.nsw.gov.au (Accessed 23 December 2013).

NSW Office of Environment and Heritage (2013c) *Corporate Plan 2014-17*, Sydney, State of NSW and NSW Office of Environment and Heritage.

NSW Office of Environment and Heritage (2014b) *Ecological Thinning Trial in NSW and Victorian River Red Gum Forests: Public environment report*, Sydney, Prepared by NSW Office of Environment and Heritage, NSW National Parks and Wildlife Service, Victorian Department of Environment and Primary Industries, and Parks Victoria with the assistance of AECOM Australia Pty Ltd and Regeneration Solutions Pty Ltd.

NSW Office of Environment and Heritage (2008) *Fire Management Strategy – Bullawa Creek State Conservation Area Zone 3*, Narrabri, NSW Office of Environment and Heritage.

NSW Office of Environment and Heritage (2014c) "Glossy black-cockatoo," [online] Available from: http://www.environment.nsw.gov.au/animals/GlossyBlackCockatoos.htm (Accessed 17 April 2014).

NSW Office of Environment and Heritage (2013d) "Grazing study," [online] Available from: http://www.environment.nsw.gov.au/policies/grazingStudy.htm (Accessed 31 March 2014).

NSW Office of Environment and Heritage (2006) *Managing invasive native scrub – info sheet no. 9*, Sydney, NSW Office of Environment and Heritage.

NSW Office of Environment and Heritage (2012a) *Oolambeyan National Park – Draft Plan of Management*, Sydney, NSW Office of Environment and Heritage.

NSW Office of Environment and Heritage (2013e) "Plans of Management," [online] Available from: environment.nsw.gov.au/parkmanagement/ParkManagementPlans.htm (Accessed 20 December 2013).

NSW Office of Environment and Heritage (2012b) *Regional Pest Management Strategy 2012-17: Northern Plains Region – a new approach for reducing impacts on native species and park neighbours*, Sydney, NSW Office of Environment and Heritage.

NSW Office of Environment and Heritage (2014d) "Research in the river red gum parks," [online] Available from: http://www.environment.nsw.gov.au/newparks/riverredgums/rrgresearch.htm (Accessed 27 March 2014).

NSW Office of Environment and Heritage and Parks Victoria (2012) *Ecological Thinning Trial in NSW and Victorian River Red Gum Reserves – Experimental Design and Monitoring Plan*, NSW Office of Environment and Heritage (Scientific Services Division and Parks and Wildlife Group) and Parks Victoria.

Parma, A., Amarasekare, P., Mangel, M., Moore, J., Murdoch, W., Nooburg, E., Pascual, A., Possingham, P., Shea, K., Wilcox, C. and Yu, D. (1998) "What can adaptive management do for our fish, forests, food and biodiversity?," *Integrative Biology, Issues, News and Reviews*, 1(1), pp. 16–26.

Parnaby, H., Lunney, D. and Fleming, M. (2011) "Management of hollow-using bats of the Pilliga forests," In Law, B., Eby, P., Lunney, D., and Lumsden, L. (eds.), *The Biology and Conservation of Australasian Bats*, Sydney, Royal Zoological Society of New South Wales, pp. 399–420.

Parsons Brinckerhoff Pty Limited (2008) *Namoi – 2030 Regional Resource Strategy Issues Paper – Overview*, [online] Available from: narrabri.nsw.gov.au/files/uploaded/file/Planning and Development/Namoi 2030 Issues Paper Overview.pdf .

Paull, D. C. and Date, E. M. (1999) "Patterns of decline in the native mammal fauna of the north-west slopes of New South Wales," 31(June), pp. 210–224.

Pinchot Institue for Conservation (2014) *The role of communities in stewardship contracting - FY 2013 programmatic monitroing report to the USDA forest service*, Washington, DC, Pinchot Institue for Conservation.

Preston, B. (2006) *Principles of Ecologically Sustainable Development*, Sydney, Presentation to the National Trust Corporate Breakfast, 23 November 2006.

Priday, S. (2010) "Beyond the 'woody remnant' paradigm in conservation of woodland birds: habitat requirements of the Hooded Robin (Melanodryas cucullata cucullata)," *Emu*, 110, pp. 118–124.

Prober, S., Lunt, I. and Thiele, K. (2008) "Effects of fire frequency and mowing on a temperate, derived grassland soil in south-eastern Australia," *International Journal of Wildland Fire*, 17(5), pp. 586–94.

Pyne, S. (1992) *Burning Bush: A fire history of Australia*, Sydney, Allen and Unwin.

Rayner, L., Ellis, M. and Taylor, J. E. (2014) "Hollow occurrence and abundance varies with tree characteristics and among species in temperate woodland Eucalyptus," *Austral Ecology*, 39(2), pp. 145–157, [online] Available from: http://doi.wiley.com/10.1111/aec.12052 (Accessed 26 March 2014).

Reid, N. (2010) *Can ecosystem services concepts support integrated land use planning? Report to the Minerals Council of Australia on "Regional Resource Planning: Opportunities to Advance Two Think-pieces,"* Armidale, Ecosystem Management, School of Environmental and Rural Science, University of New England.

Resource and Conservation Assessment Council (2002) *Preliminary Overview of the Brigalow Belt South Bioregion (Stage 1), NSW Western Regional Assessments Brigalow Belt South Stage 1*, Sydney, Resource and Conservation Assessment Council.

Rist, L., Campbell, B. and Frost, P. (2013) "Adaptive management: where are we now?," *Environmental Conservation*, 40(1), pp. 5–18.

Rolls, E. (1981) *A Million Wild Acres*, Melbourne, Thomas Nelson.

Ross, K. A., Bedward, M., Ellis, M. V, Deane, A., Simpson, C. C. and Bradstock, R. A. (2008) "Modelling the dynamics of white cypress pine Callitris glaucophylla woodlands in inland south-eastern Australia," *Ecological Modelling*, 211(1-2), pp. 11–24, [online] Available from: http://linkinghub.elsevier.com/retrieve/pii/S0304380007004218 (Accessed 20 March 2014).

Ruhl, J. (2005) "Regulation by Adaptive Management – Is It Possible?," *Minnesota Journal of Law, Science & Technology*, 21, pp. 34–53.

Ruhl, J. and Fischman, R. (2010) "Adaptive Management in the Courts," *Minnesota Law Review*, 95, pp. 424–484.

Rumpff, L. (2011) "The process in making adaptive management meaningful - using process models to guide investment of native vegetation," *Decision Point*, 47, pp. 4–6, [online] Available from: http://ceed.edu.au/wp-content/uploads/2011/03/DPoint_47.pdf.

Rural Industries Research and Development Corporation (2013) "Rural Industries Research and Development Corporation Honeybee Research and Development Program Overview," [online] Available from: http://www.rirdc.gov.au/research-programs/animal-industries/honeybee (Accessed 28 April 2014).

Ryan, D., Ryan, J. and Starr, B. (1995) *The Australian Landscape – observations of explorers and early settlers*, Wagga Wagga, Murrumbidgee Catchment Management Committee.

Shelly, D. (2013) "Preliminary fauna survey of belah and cypress/box woodland near West Wyalong NSW and recommendations for forest management," *Australian Forestry*, 61(2), pp. 147–154.

Shultz, C. and Nie, M. (2012) "Decision-making Triggers, Adaptive Management, and Natural Resources Law and Planning," *Natural Resources Journal*, 52, pp. 449–451.

Slocombe, D. (1998) "Defining Goals and Criteria for Ecosystem-Based Management," *Environmental Management*, 22(4), pp. 483–493.

Sluiter, I., Allen, G., Morgan, D. and Walker, I. (1997) *Vegetation responses to stratified kangaroo grazing pressure at Hattah-Kulkyne National Park, 1992-96 - Flora and fauna technical report: No. 149, Flora and Fauna Technical Report No. 14*, East Melbourne, Department of Natural Resources and Environment.

Smit, B. and Wandel, J. (2006) "Adaption, adaptive capacity and vulnerability," *Global Environmental Change*, 16, pp. 282–292.

Somerville, D. (1997) *Beekeeping in the Dubbo State Forests, NSW*, Goulburn, NSW Agriculture.

South African National Parks (2008) *A framework for developing and implementing management plans for South African National Parks*, Pretoria.

Spooner, P. and Allcock, K. (2006) "Using a state-and-transition approach to manage endangered Eucalyptus albens (White Box) woodlands: White Box woodland state-and-transition model," *Journal of Environmental Management*, 38(5), pp. 771–783.

Stankey, G. and Allen, C. (2009) "Introduction," In Allen, C. and Stankey, G. (eds.), *Adaptive Environmental Management: A Practitioner's Guide*, Collingwood, CSIRO Publishing.

Stankey, G., Bormann, B., Ryan, C., Shindler, B., Sturtevant, V., Clark, R. and Philpot, C. (2003) "Adaptive management and the Northwest Forest Plan - Rhetoric and Reality," *Journal of Forestry*, 101, pp. 40–46.

Stankey, G., Clark, R. and Bormann, B. (2005) *Adaptive Management of Natural Resources: Theory, Concepts, and Management Institutions*, Portland, Oregon, United States Department of Agriculture - Forest Service.

State Forests of NSW (2000) *Native forests silviculture manual*, Pennant Hills, State Forests of NSW, State Government of NSW.

Stedman, R. C., Parkins, J. R. and Beckley, T. M. (2004) "Resource dependence and community wellbeing in rural Canada," *Rural Sociology*, 69(2), pp. 213–234.

Stephens, M. (2013) *Active forest fire management for multiple landscape benefits in the United States and Canada*, 2013 Gottstein Fellowship Report, Joseph William Gottstein Memorial Trust Fund.

Susskind, L., Camacho, A. and Schenk, T. (2012) "A critical assessment of collaborative adaptive management in practice," *Journal of Applied Ecology*, 49, pp. 47–51.

Thompson, W. and Eldridge, D. (2005a) "Plant cover and composition in relation to density of Callitris glaucophylla (white cypress pine) along a rainfall gradient in eastern Australia," *Australian Journal of Botany*, 53, pp. 545–554.

Thompson, W. and Eldridge, D. (2005b) "White cypress pine (Callitris glaucophylla): A review of its roles in landscape and ecological processes in eastern Australia," *Australian Journal of Botany*, 53(6), pp. 555–570.

Turland, J. (2003) *Tree level modelling in western New South Wales; uneven-aged mixed species forests*, Wellington, Proceedings of the Australian and New Zealand Institute of Forestry Conference.

U.S. Department of the Interior (2013) "BLM stewardship contracting: Q's and A's," [online] Available from: http://www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/0.Par.58994.File.dat/stcontrBLM_QAs0115.pdf (Accessed 29 May 2014).

United States Department of Agriculture (2012) *Increasing the Pace of Restoration and Job Creation on Our National Forests*, Washington, DC, United States Department of Agriculture - Forest Service.

United States Department of Agriculture Forest Service (2009a) "Stewardship Contracting - Basic stewardship contracting concepts," United States Department of Agriculture - Forest Service.

United States Department of Agriculture Forest Service (2009b) "Stewardship Contracting - Basic stewardship contracting concepts," United States Department of Agriculture - Forest Service, [online] Available from: http://www.fs.fed.us/restoration/documents/stewardship/stewardship_brochure.pdf (Accessed 18 May 2014).

Wells, K., Laut, P. and Wood, N. (1984) *Loss of forests and woodlands in Australia - A summary by state, based on rural local government areas, CSIRO Technical Memorandum 84/4*, Canberra, CSIRO.

Western Research Institute Ltd (2013) *Regional Development Australia Orana Profile and Opportunities*, Bathurst, A report prepared for Regional Development Australia Orana.

Westgate, M., Likens, G. and Lindenmayer, D. (2013) "Adaptive management of biological systems: A review," *Biological Conservation*, 158, pp. 128–139.

Westoby, M., Walker, B. and Noy-Meir, I. (1989) "Opportunistic management for rangelands not at equilibrium," *Journal of Range Management*, 42(4), pp. 266–274.

Whipp, R. K., Lunt, I. D., Deane, A. and Spooner, P. G. (2009) "Historical forest survey data from Eucalyptus - Callitris forests: a valuable resource for long-term vegetation studies," *Australian Journal of Botany*, 57(7), p. 541.

Whipp, R., Lunt, I., Spooner, P. and Bradstock, R. (2012) "Changes in forest structure over 60 years: tree densities continue to increase in the Pilliga forests, New South Wales, Australia," *Australian Journal of Botany*, 60(1), pp. 1–8.

Williams, B. (2011) "Adaptive management of natural resources - framework and issues," *Journal of Environmental Management*, 92, pp. 1346–1353.

Wilson, A., Oxley, R. and Bratby, W. (1997) *A grazing management strategy for Buckingbong State Forest*, Parramatta, Department of Land & Water Conservation and State Forests of NSW.

Wintle, B., Runge, M. and Bekessy, S. (2010) "Allocating monitoring effort in the face of unknown unknowns," *Ecology letters*, 13(11), pp. 1325–1337.

Wyatt, S. (1989) "John Oxley's exploration of the Pilliga forests," *Forest Timber*, 25, pp. 20–24.

Young, T., Petersen, D. and Clary, J. (2005) "The ecology of restoration: historical links, emerging issues and unexplored realms," *Ecology Letters*, 8(6), pp. 662–673.

Part III - Attachments

Attachment 1 -Terms of Reference

Terms of Reference

Adaptive and Active Management of Cypress Forests in Brigalow and Nandewar State Conservation Areas

The Premier requests the Commission to:

1. consistent with the objects of the *National Parks and Wildlife Act 1974* and specifically the principles of ecological sustainable development, assess the potential environmental and socio-economic impacts and benefits of undertaking adaptive and active management processes in Brigalow and Nandewar State Conservation Areas. State Conservation Areas (Zone 3) are areas where the management objectives are conservation, recreation and mineral extraction
2. identify approaches, methods and suggested next steps as options to develop an active and adaptive management program for cypress forests to maintain and enhance environmental values in Brigalow and Nandewar State Conservation Areas.

The Commission should consider, in the context of ecological sustainable development the:

- current ecological value of the forest and future values under different adaptive and active management options and processes
- current social and economic impacts and benefits of the forest and future social and economic values under different adaptive and active management options and processes
- commercial opportunities derived from adaptively managing these forests, including costs and benefits of silvicultural or thinning programs
- appropriate mechanisms that could ensure accountability, track performance and facilitate adaptive management
- relevant legislation, agreements and management plans such as the NSW *Brigalow and Nandewar Community Conservation Area Act 2005,* Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* and the *Brigalow and Nandewar Integrated Forests Operations Agreement.*

The Commission should also provide advice on any change to regulation and financial support, if any, necessary to support any options.

The Commission should work closely with key agencies and undertake targeted consultation as required with relevant industry, community and environmental groups.

The Commission is to provide the Minister with a report, including draft recommendations and options within 3 months of receiving the terms of reference, with final report to follow.

Attachment 2 - Community Conservation Areas Zone 3 – State Conservation Areas

State Conservation Area (CCA Z3)	Size (hectares)	Date created	Plan of management	Prioritised regional pest program	Fire management strategy
Adelyne	148	1/01/2011	No	Yes	Jun 2012
Beni	1,849	1/12/2005	No	Yes	Jun 2009
Biddon	3,352	1/12/2005	Yes – Oct 2012	Yes	Apr 2013
Bingara	1,979	1/12/2005	No	Yes	Jun 2008
Bobbiwaa	2,688	1/12/2005	No	Yes	Apr 2009
Bullawa Creek	99	1/12/2005	Yes – Nov 2012	Yes	Sept 2008
Cobbora	2,261	24/12/2010	No	Yes	No
Durridgere	6,172	1/12/2005	No	Yes	Jun 2009
Goodiman	569	1/12/2005	No	Yes	Jun 2009
Goonoo	54,522	1/12/2005	No	Yes	Aug 2009
Goonoowigal	1,055	1/12/2005	No	Yes	Jun 2008
Gwydir River	2,607	1/12/2005	No	Yes	Aug 2006
Killarney	1,858	1/12/2005	No	Yes	Apr 2009
Leard	1,176	1/12/2005	Yes – Nov 2012	Yes	Apr 2009
Merriwindi	1,730	1/12/2005	No	Yes	Oct 2009
Pilliga	33,386	1/12/2005	No	Yes	Jun 2009
Pilliga East	24,669	1/12/2005	No	Yes	May 2012
Pilliga West	34,415	1/12/2005	No	Yes	Jun 2009
Tingha Plateau	3,414	1/01/2011	No	Yes	Aug 2008
Trinkey	10,229	1/12/2005	Draft – Feb 2012	Yes	Sept 2013
Warialda	2,913	1/12/2005	No	Yes	Jun 2008
Wondoba	1,663	1/12/2005	Draft – Feb 2012	Yes	Sept 2013
Woodsreef	331	1/01/2011	No	Yes	Aug 2012

Attachment 3 -NRC spatial analysis

The NRC used spatial data to assess and quantify the potential environmental and socio-economic impacts and benefits of undertaking adaptive and active management processes in Brigalow and Nandewar State Conservation Areas.

For this review, the NRC selected existing ADS40 imagery (captured between 2009 and 2012) as the primary data source to underpin its spatial analysis. ADS40 imagery allowed for the effective detection and classification of white cypress pine. However, some of the imagery varied in quality which may have resulted in some over- and under-estimation of the presence, extent and canopy coverage of white cypress pine. It also allowed the NRC to apply a consistent, objective and cost-effective method across all State Conservation Areas.

Although the ADS40 analysis represents a significant improvement on past approaches, there are some limitations, challenges and areas for further improvement including:

- achieving improved separation between white cypress pine (*Callitris glaucophylla)*, bulloak (*Allocasuarina luehmannii)*, rough barked apple (*Angophora floribunda)* and *Acacia* species within image classification
- providing stronger differentiation between eucalypt species to generate robust eucalypt to white cypress pine ratios
- accounting for disturbances after the capture date of remotely sensed data.

The NRC also captured new LiDAR data over 5 State Conservation Areas to analyse and describe the structure and composition of vegetation and estimate timber volumes. The NRC determined that capturing LiDAR data across all State Conservation Areas was cost prohibitive.

Figure A3.1 and **Table A3.1** outline the steps undertaken in the NRC's analysis, the resultant outputs and links to more detailed information.

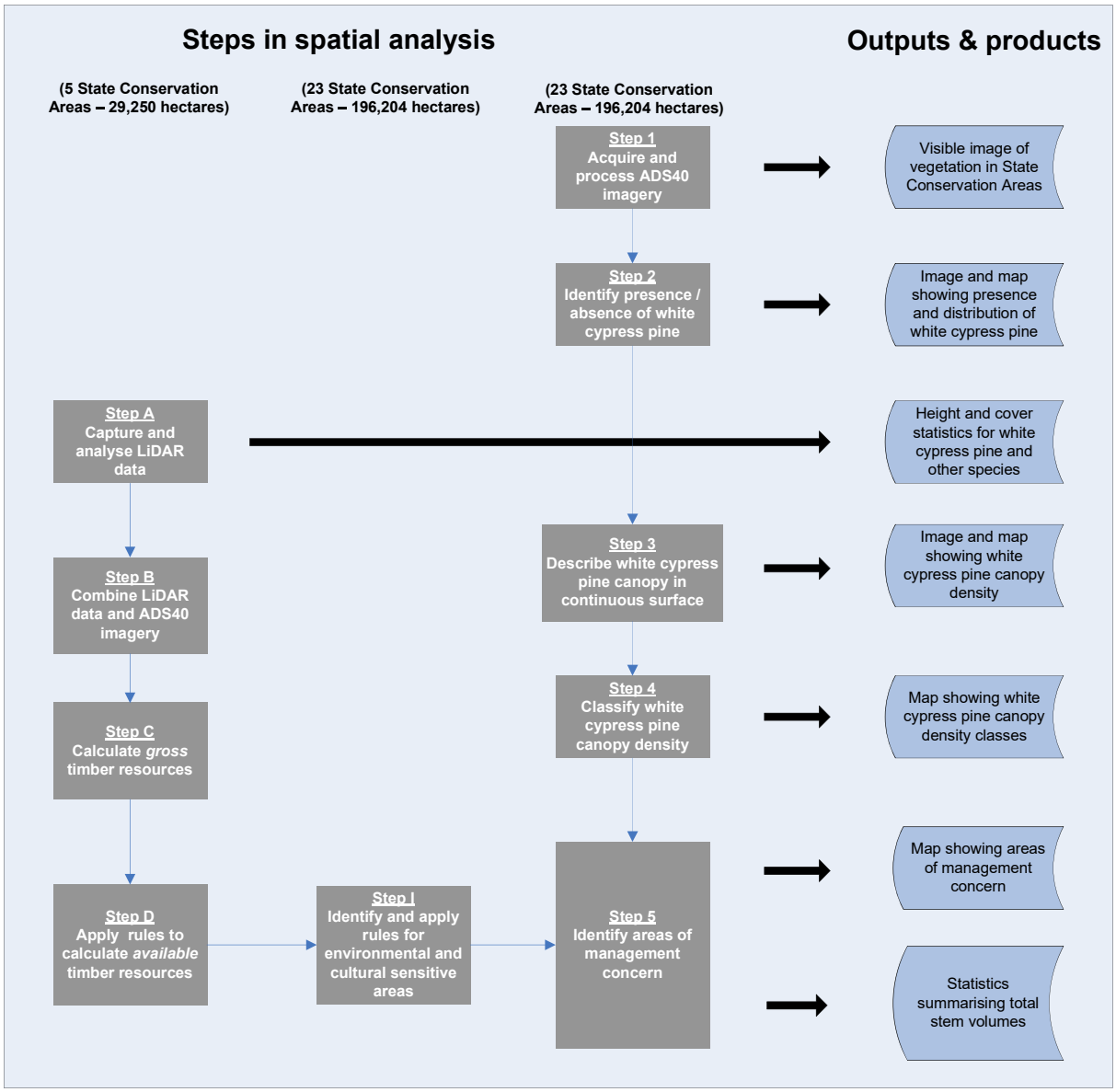


Figure A3.1: Steps, outputs and products of spatial analysis

Table A3.1: Overview of spatial analysis

Step (refer to figure A3.1. for relevant numbers, numerals and letters)		Description	References and further links
1	**Acquire and processADS40 image**	▪ Data sourced from NSW Land and Property Information and Office of Environment and Heritage ▪ Leica ADS40 image mosaics captured between 2009-2012 (50cm pixel resolution, bands Red Green Blue ▪ 75 grid cells with each polygon covering 10,000 hectares (combined area of 750,000 hectares), subsequently used to clip the original mosaics into smaller raster tiles (GeoTIFF format)	▪ Remote Census (2013) *SPOT 5 and ADS40 trial for Pilliga West.* A technical paper commissioned by the NSW Natural Resources Commission ▪ Remote Census (2014) *Classifying white cypress pine distribution with digital aerial imagery in the Brigalow Nandewar State Conservation Areas (Community Conservation Area Zone 3).* A technical paper commissioned by the NSW Natural Resources Commission. ▪ See **Figure A3.2** for extent of ADS40 coverage ▪ See **Table A3.2** for discussion on issues and confidence levels for spatial products ▪ See NRC's *Draft report supporting profile and map book* for ADS40 Red Green Blue images

Step (refer to figure A3.1. for relevant numbers, numerals and letters)		Description	References and further links
2	**Identify presence/absence of white cypress pine**	▪ Red Green Blue images classified into new composite bands using a series of algorithms to generate Cypress Vegetation Model. Higher pixel values in continuous variable rasters then predicted presence of white cypress pine crowns ▪ Mask used to remove Cypress Vegetation Model pixels outside of the designated State Conservation Area boundary, generated by initially buffering the State Conservation Area vector boundary by 50 metres and then converting the buffered vector to a raster mask. Cypress Vegetation Models were later converted to binary masks by using a threshold cut-off value ▪ The NRC selected five classes to characterise cypress canopy percentage coverage in each State Conservation Area in consultation with agency stakeholders and technical experts. Class 4 was selected as the ceiling class (where white cypress pine densities are greater than 31 percent), as there were only limited areas in State Conservation Areas where the number of pixels that contain white cypress pine crowns were greater than this amount ▪ An independent validation survey was conducted to confirm Cypress Vegetation Model classification reliability. The survey was undertaken within the three test sites and involved the measurement of over 100 field plots. The study compared ADS40 classifications with field data and concluded that the Cypress Vegetation Model had an overall reliability of 87 percent (weighted by tree size) across the three test sites	▪ Remote Census (2013) *SPOT 5 and ADS40 trial for Pilliga West*. A technical paper commissioned by the NSW Natural Resources Commission ▪ Remote Census (2014) *Classifying white cypress pine distribution with digital aerial imagery in the Brigalow Nandewar State Conservation Areas (Community Conservation Area Zone 3).* A technical paper commissioned by the NSW Natural Resources Commission ▪ Eco Logical Australia (2014) *Mapping White Cypress Pine Callitris glaucophylla with ADS40 imagery. A field validation to determine product accuracy and reliability.* A technical paper commissioned by the NSW Natural Resources Commission.

Step (refer to figure A3.1. for relevant numbers, numerals and letters)		Description	References and further links
3	**Describe white cypress pine canopy in continuous surface layer**	▪ Cypress Vegetation Model binary masks were converted to a continuous Canopy Cover Percentage surface raster layer to provide a surrogate estimate of white cypress pine stand density ▪ The Canopy Cover Percentage surface raster layer represents the proportion of area covered by white cypress pine pixels within a moving circular search window. These continuous variable surfaces contained pixel values ranging from 0 to 100 percent. Initially, window sizes of 10m and 25m radius (approximately 0.03 and 0.2 hectares respectively) were evaluated relative to the independent field survey data (Eco Logical Australia 2014)	▪ Remote Census (2014) *Classifying white cypress pine distribution with digital aerial imagery in the Brigalow Nandewar State Conservation Areas (Community Conservation Area Zone 3)*. A technical paper commissioned by the NSW Natural Resources Commission ▪ Eco Logical Australia (2014) *Mapping White Cypress Pine Callitris glaucophylla with ADS40 imagery. A field validation to determine product accuracy and reliability*. A technical paper commissioned by the NSW Natural Resources Commission ▪ See NRC's *Draft report supporting profile and map book* for white cypress pine canopy surface layer

Step (refer to figure A3.1. for relevant numbers, numerals and letters)		Description	References and further links
4	**Classify white cypress pine canopy density**	▪ Canopy Cover Percentage rasters were re-classified into new rasters with 4 categorical classes based on the following thresholds 1 to 10 percent; 10 to 20 percent; 20 to 30 percent; and greater than 30 percent to generate Canopy Cover Surface vectors ▪ The categorical rasters were subsequently converted to GIS vectors (for example, ArcGIS shapefiles). Due to the large size of the tiled shapefiles (ranging up to 64 megabytes) they were not merged or combined into larger files ▪ An independent validation survey was conducted to confirm reliability of Canopy Cover Percentage classes. The survey was undertaken within the three test sites and involved the measurement of over 100 field plots. The study compared Canopy Cover Percentage classes with field data and concluded that the Canopy Cover Percentage had an overall reliability of accuracy of 73 percent across the three test sites	▪ Remote Census (2014) *Classifying white cypress pine distribution with digital aerial imagery in the Brigalow Nandewar State Conservation Areas (Community Conservation Area Zone 3)*. A technical paper commissioned by the NSW Natural Resources Commission ▪ Eco Logical Australia (2014) *Mapping White Cypress Pine Callitris glaucophylla with ADS40 imagery. A field validation to determine product accuracy and reliability*. A technical paper commissioned by the NSW Natural Resources Commission ▪ See NRC's *Draft report supporting profile and map book* for white cypress pine canopy class mapping
5	**Identify potential areas of management concern**	▪ The NRC applied the framework and criteria to Canopy Cover Percentage rasters to generate categories for potential areas of management concern and acceptable condition ▪ Apply rule set for environmental and culturally sensitive areas (Step I)	▪ See **Table A3.3** for framework and criteria. ▪ See NRC's *Draft report supporting profile and map book* for white cypress pine canopy class mapping

Step (refer to figure A3.1. for relevant numbers, numerals and letters)		Description	References and further links
I	**Develop rules for environmental and culturally sensitive areas**	▪ Decision rules were compiled to identify sensitive environmental and cultural values that could either (i) exclude interventions or (ii) manage risks if interventions occur ▪ Compiled from key indicators relating to protection of environmental values and limitations to forestry operations from the Private Native Forestry Code of Practice for Cypress and Western Hardwood Forests, and the Integrated Forestry Operations Approval for the Brigalow Nandewar Region ▪ Decision rules were translated into spatial constraint surfaces	▪ See **Table A3.4** for rule set ▪ Eco Logical Australia (2014) *Characterisation of White Cypress Pine Callitris glaucophylla forests in the Pilliga region of NSW – spatial analyses using LiDAR, ADS40 and stem volume information*. A technical paper commissioned by the NSW Natural Resources Commission ▪ See NRC's *Draft report supporting profile and map book* for environmental and cultural sensitive areas mapping

Step (refer to figure A3.1. for relevant numbers, numerals and letters)		Description	References and further links
A	**Capture and analyse LiDAR data**	▪ The cypress mask generated by Forestry Corporation of NSW was 'smoothed' by applying an averaging algorithm in ArcGIS to each cell that considered the 'average' height of all cells within a 25m radius ▪ Cumulative canopy-height charts were generated for white cypress pine and other species at each of the five State Conservation Areas, by calculating the total area of cypress mask and non-mask occurring within each 1 metre height increment (using the original canopy height model generated by Forestry Corporation of NSW), then plotting the total percentage return (mask and non-mask) from ground level to changes in height ▪ Percent-cover charts were also generated for each State Conservation Area that showed the relative contribution of white cypress pine cover and non-white cypress pine cover within four height bands ▪ The canopy mask provided by Forestry Corporation of NSW was intersected with the 'greater than 3 metre' height band in the 'smoothed' canopy height layer to generate a 0 to 3 metre cypress mask that would normally be associated with 'locked' cypress. The resultant binary layer (1 = white cypress pine, 0 = non-white cypress pine) was smoothed by applying an averaging function to each pixel that considered all pixels within 25 metre radius, before the surface was re-classified into seven cypress cover classes	▪ Eco Logical Australia (2014) *Characterisation of White Cypress Pine Callitris glaucophylla forests in the Pilliga region of NSW – spatial analyses using LiDAR, ADS40 and stem volume information*. A technical paper commissioned by the NSW Natural Resources Commission
B	**Combine LiDAR and ADS40 imagery**	▪ Apply spectral classification to identify white cypress pine crowns using Principle Components Analysis, stretching all four principle components from 0 to 255. Then apply reverse principle components transformation on stretched principle components to produce de-correlated image bands ▪ Rectify ADS40 image with LiDAR CHM to ensure tree crowns of all species within the images to coincide with LiDAR-defined crowns. This enables correct attribution of LiDAR derived heights to white cypress pine crowns once these had been identified in the images	▪ Forestry Corporation of NSW (2014) *Image analysis for identification of white cypress*

Step (refer to figure A3.1. for relevant numbers, numerals and letters)		Description	References and further links
C	**Calculate gross timber resources**	▪ Total stem volumes are calculated in the Forestry Corporation of NSW's inventory data base using the formula from Baalman (2002) ▪ Raster layer incorporates merchantable white cypress pine trees in the area, with each white cypress pine stem less than 12 metres height represented as a 1 by 1 metre pixel. Similarly, a total stem volume (cubic metres) raster incorporates all white cypress pine trees in the area, with each white cypress pine stem ≥ 3 m height represented as a 1 by 1 metre pixel ▪ Analysis of the total number of stems and total production volume for white cypress pine stems greater than 12 metres was undertaken in each State Conservation Area by tallying the production volume values of all 1 by 1 metre pixels. ▪ An analysis of the total number of stems and total stem volume for white cypress pine stems equal to or greater than 3 metres was also undertaken in each State Conservation Area by tallying the stem volume values of all 1 by 1 metre pixels	▪ Baalman, E (2002) *Volume and taper equations for NSW White Cypress pine, Technical Report #8* ▪ Forestry Corporation of NSW (2014) *White cypress volume predictions using LIDAR derived heights for Pilliga and Gunnedah management areas* ▪ Eco Logical Australia (2014) *Characterisation of White Cypress Pine Callitris glaucophylla forests in the Pilliga region of NSW – spatial analyses using LiDAR, ADS40 and stem volume information.* A technical paper commissioned by the NSW Natural Resources Commission
D	**Apply rules to calculate available timber resources**	▪ Rule set applied to gross timber values to estimate likely available timber resources including retention of habitat and recruitment trees, retention of stands of low basal area, and retention in areas recently subject to fire and previous harvesting	▪ See **Table A3.5** for rule set ▪ Eco Logical Australia (2014) *Characterisation of White Cypress Pine Callitris glaucophylla forests in the Pilliga region of NSW – spatial analyses using LiDAR, ADS40 and stem volume information.* A technical paper commissioned by the NSW Natural Resources Commission

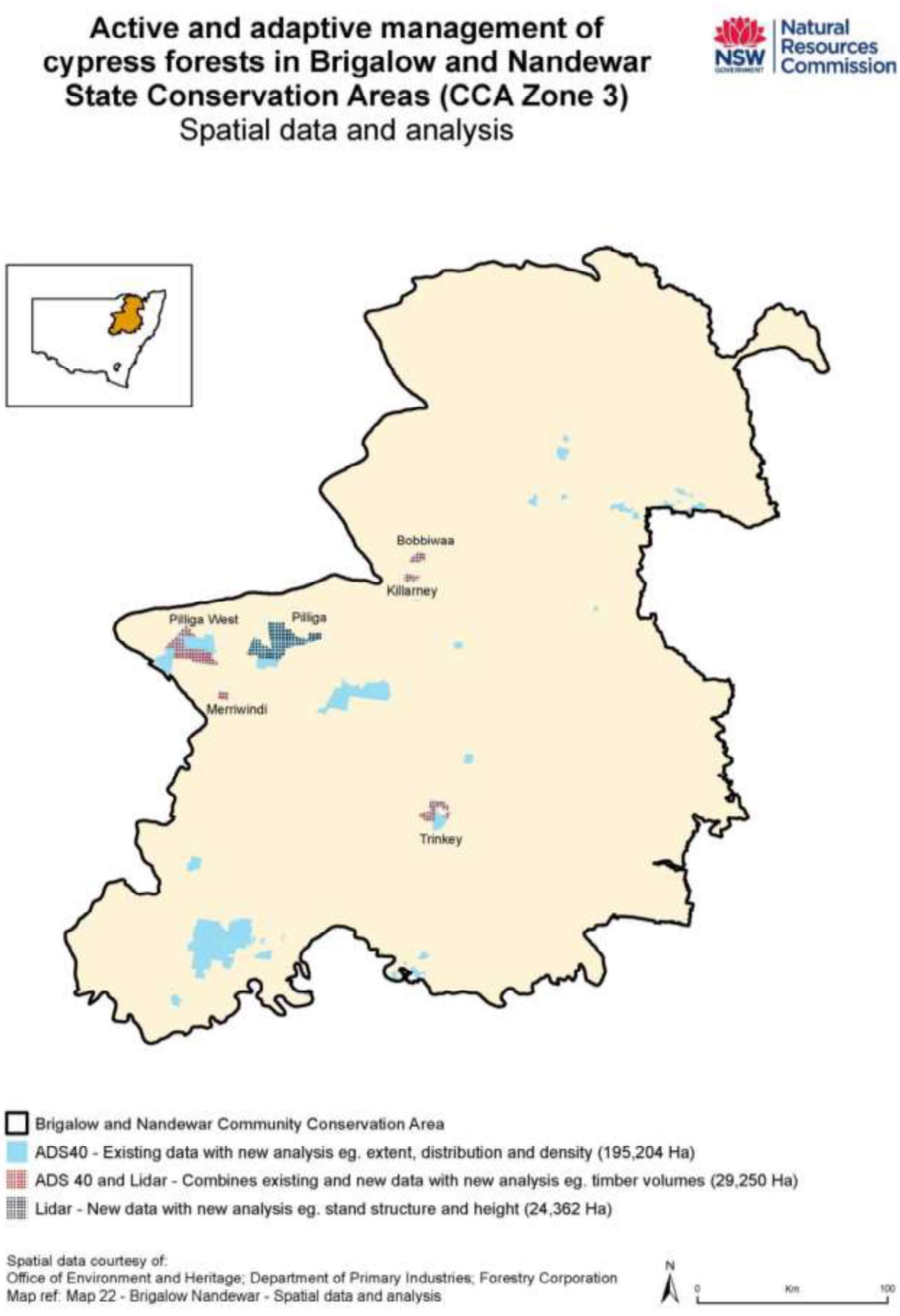


Figure A3.2: Extent and coverage of spatial data capture and analysis

Table A3.2: Summary of issues and confidence levels for spatial products

State Conservation Area	ADS40 image quality	Issues	Confidence levels
1. Adelyne	High	Image classification and mapping includes other species	Lower
2. Beni	High	-	Higher
3. Biddon	High	-	Higher
4. Bingara	Medium	Image classification and mapping includes other species	Lower
5. Bobbiwaa	High	-	Higher
6. Bullawa Creek	Medium	-	Lower
7. Cobbora	Medium - high	-	Higher
8. Durridgere	Medium - high	Image classification and mapping includes other species	Lower
9. Goodiman	High	-	Higher
10. Goonoo	Low- high	Fire regrowth	Lower
11. Goonoowigal	High	Image classification and mapping includes other species	Lower
12. Gwydir River	Medium	Image classification and mapping includes other species	Lower
13. Killarney	High	-	Higher
14. Leard	High	-	Higher
15. Merriwindi	High	-	Higher
16. Pilliga	High	Image classification and mapping includes other species in north eastern section	Higher
17. Pilliga East	Low- high	Image classification and mapping includes other species and regrowth after fire	Lower
18. Pilliga West	Medium - high	-	Higher

State Conservation Area	ADS40 image quality	Issues	Confidence levels
19. Tingha Plateau	High	-	Higher
20. Trinkey	High	Image classification and mapping includes other species in south western section	Higher
21. Warialda	Medium - high	Image classification and mapping includes other species	Lower
22. Wondoba	High	-	Higher
23. Woodsreef	High	Image classification and mapping includes other species	Lower

TableA3.3: Criteria for identifying areas of acceptable condition and management concern

		Criteria	Key rationale
Areas of acceptable condition		**A** All areas with little or no white cypress pine detected **B** All white cypress pine canopy classes 1-4 (between 1 and 100 percent canopy coverage) with patch sizes less than 1 hectare **C** Cypress canopy percentage class 1 (1 - 10 percent canopy coverage) with patch sizes greater than 1 hectare	▪ Within acceptable levels of natural variability occurring ▪ Minimal impact on environmental values ▪ Retains small patches of white cypress pine in the landscape
Areas of management concern	Transitional state	**D** White cypress pine canopy class 2 (11 - 20 percent canopy coverage) with patch sizes greater than 1 hectare	▪ Nearing thresholds of management concern ▪ Impact on future environmental values ▪ Retains small, more dense patches of white cypress pine in the landscape ▪ Some areas are likely to be more ecologically or culturally sensitive than others ▪ Assumes loss of white cypress pine stands due to wildfire
	Undesirable states	White cypress pine canopy class 3 (21 - 30 percent canopy coverage) with patch sizes greater than 1 hectare **E** White cypress pine canopy class 4 (greater than 31 percent canopy coverage) with patch sizes greater than 1 hectare	▪ Crossed thresholds of management concern ▪ Impact on current and future environmental values ▪ Retains small, more dense patches of white cypress pine in the landscape ▪ Some areas are likely to be more ecologically or culturally sensitive than others ▪ Assumes loss of white cypress pine stands due to wildfire

Notes:

- All areas reported for classes in areas of acceptable condition (A, B and C) **include** sensitive environmental and cultural areas and areas that have had recent wildfires.
- All areas reported for classes in the areas of management concern (D, E and F) **exclude** sensitive environmental and cultural areas that have had recent wildfire events.

Table A3.4: Environmental and cultural values rule set

Theme	Rule set criterion	Reference	Action	Data	Custodian
Cultural Heritage	**Aboriginal Object or Place** Burial site – 50 metre buffer Scarred / Carved Tree – 20 metre buffer Aboriginal Place – 10 metre buffer	Integrated Forestry Operations Approval (Cl. 100) Private Native Forestry Code of Practice (Table C)	Exclude management	Aboriginal Heritage Information Management System (AHIMS) database	Office of Environment and Heritage
Heritage	Identified heritage items in an environmental planning instrument – 10 metre buffer	Private Native Forestry Code of Practice (Table C)	Exclude management	No records of historic heritage items in Historic Heritage Information Management System (HHIMS) or the State Heritage Register. Data developed for earlier assessments (Curby & Humphries, 2002) was unavailable.	P&I
Drainage	**Stream order buffers** Unmapped drainage line - 5 metres buffer Mapped first-order streams - 10 metres buffer Mapped second-order streams - 20 metres buffer Mapped third-order streams - 30 metres buffer Mapped fourth-order streams - 40 metres buffer Mapped fifth-order and higher streams - 50 metres buffer	Integrated Forestry Operations Approval (cl.106)	Exclude management	Hydrolines – ordered streams	LPI/P&I
	Wetland Areas + buffer 0.01 - 0.5 hectares - 10 metres buffer Greater than 0.5 hectares - 20 metres buffer	Integrated Forestry Operations Approval (cl. 108) Private Native Forestry Code of Practice (Table C)	Exclude management	Vegetation / NSW wetlands / Ramsar	OEH/GA

Theme	Rule set criterion	Reference	Action	Data	Custodian
Threatened Fauna	**Within buffer of record (less than 20 years age with reliability level 1-5)** Black-throated finch (*Poephila cincta cincta*) - 100 metres Black-striped wallaby (*Macropus dorsalis*) - 500 metres Brush-tailed phascogale (*Phascogale tapoatafa*) - 500 metres Grass owl (*Tyto capensis*) - 100 metres Long-haired rat (*Rattus villosissimus*) - 100 metres Hopping mouse (*Notomys* spp.) - 100 metres Pale-headed snake (*Hoplocephalus bitorquatus*) - 100 metres (additional 200m from May - Sept) Parma wallaby (*Macropus parma*) - 100 metres Pied honeyeater (*Certhionyx variegatus*) - 100 metres Powerful owl (*Ninox strenua*) - 1000 metres Red goshawk (*Erythrotriorchis radiatus*) - 5000 metres Rufous bettong (*Aepyprymnus rufescens*) - 100 metres Squatter pigeon (*Geophaps scripta*) - 100m Stripe-faced dunnart (*Sminthopsis macroura*) - 100 metres Zigzag velvet gecko (*Oedura rhombifer*) - 100 metres Eastern pygmy-possum (*Cercartetus nanus*) – 50 metres	Integrated Forestry Operations Approval (cl.144) Private Native Forestry Code of Practice (Appendix)	Exclude management	Atlas of NSW Wildlife / Bionet (sourced 4 April 2014)	OEH/ FCNSW/ Aust. Museum
	Within buffer of recorded (<20yrs age with reliability level 1-5) Pilliga mouse (*Pseudomys pilligaensis*) - 200 metres from recorded Squirrel glider (*Petaurus norfolcensis*) - 250 metres from recorded Barking owl (*Petaurus norfolcensis*) - 500 metres from recorded Masked owl (*Tyto novaehollandiae*) - 2 kilometres from recorded	Integrated Forestry Operations Approval (cl.251, 253 - 256) Private Native Forestry Code of Practice (Appendix)	Exclude management	Atlas of NSW Wildlife / Bionet	OEH/ FCNSW/ Aust. Museum
Threatened fauna	**Protection Zone** Brown treecreeper (eastern subspecies) nest - 20 metres	Integrated Forestry Operations Approval (cl.246)	Exclude management	Field Survey	OEH

Theme	Rule set criterion	Reference	Action	Data	Custodian
	Turquoise parrot nest - 50 metres Masked owl roost - 100 metres Barking owl major roost - 100 metres Bush stone-curlew nest - 100 metres Square-tailed kite nest - 100 metres Regent honeyeater nest - 100 metres Painted honeyeater nest - 100 metres Malleefowl nest - 100 metres Gilbert's whistler nest - 100 metres Black-breasted buzzard nest - 100 metres Grey falcon nest - 100 metres Red-tailed black-cockatoo nest - 100 metres Masked owl nest - 200 metres Barking owl nest - 200 metres Glossy black-cockatoo nest - 200 metres Yellow-bellied glider den trees - 50 metres Osprey nests - 100 metres	Private Native Forestry Code of Practice (Appendix)			
	Within buffer of recorded (less than 20 years age with reliability level 1-5) Bat roost tree - 30 metres Subterranean bat roost - 100 metres Flying fox camps - 50 metres Koalas - 100 metres of koala high use or identified core Koala habitat Spotted tailed quoll - 200 metres from a latrine/den Large-footed myotis – 30 metres buffer on all waterbodies within 100m or recorded	Integrated Forestry Operations Approval (cl.248 – 250, 252) Private Native Forestry Code of Practice (Appendix)	Exclude management	Atlas of NSW Wildlife / Bionet	OEH/ FCNSW/ Aust. Museum
Threatened Fauna	Broad-headed snake (*Hoplocephalus bungaroides*) – 100 metres Rosenberg's goanna (*Varanus rosenbergi*) – 200 metres	Private Native Forestry Code of Practice (Appendix)	Identify & manage risks	Atlas of NSW Wildlife / Bionet	OEH/ FCNSW/ Aust. Museum

Theme	Rule set criterion	Reference	Action	Data	Custodian
Threatened Flora	Protection Zone – 20 metres buffer around record *Homoranthus darwinioides* Leafless indigo *(Indigofera efoliata)* Braid fern (*Platyzoma microphyllum)* Keith's zieria (*Zieria ingramii)* Yetman wattle (*Acacia jucunda*) Rusty desert phebalium (*Phebalium glandulosum* subsp. *Eglandulosum*) Scant pomaderris (*Pomaderris queenslandica*) Greenhood orchid (*Pterostylis cobarensis*) Small purple-pea (*Swainsona recta*) Silky swainson-pea (*Swainsona sericea*) Granite boronia (*Boronia granitica*) Ovenden's ironbark (*Eucalyptus caleyi* subsp. *ovendenii*) Hawkweed (*Picris evae*) Heath wrinklework (*Rutidosis heterogama*) Protection Zone – 50 metres buffer around record Ooline (*Cadellia pentastylis*) *Bertya* sp. (Cobar–Coolabah) Protection Zone – 100 metres buffer around record Singleton mint bush (*Prostanthera cineolifera*)	Integrated Forestry Operations Approval (cl. 246, 258, 259) Private Native Forestry Code of Practice (Appendix)	Exclude management	Atlas of NSW Wildlife / Bionet	OEH/ FCNSW/ Aust. Museum
Threatened Vegetation Communities	White Box Yellow Box Blakely's Red Gum Woodland (Box Gum Woodland) Inland Grey Box Woodland	Integrated Forestry Operations Approval (cl.260, 261)	Exclude management	Vegetation	OEH

Theme	Rule set criterion	Reference	Action	Data	Custodian
Special Landscape Features	Any area of heath of more than 0.2 hectares and buffer of 30 metres Any area of rocky outcrops or cliffs and buffer of 30 metres Any caves, tunnels and disused mineshafts (excluding open pits less than 3 metres deep) - 10 metres buffer Any are of land within 30 metres of a dam or tank Any area mapped as old growth forest	Integrated Forestry Operations Approval (cl.244) Private Native Forestry Code of Practice (Table C)	Exclude management	Vegetation, Land Use, Drainage / Forest Management Zones	OEH / FCNSW / Australian Government
Soils	Highly erodible soils = dispersibility rating of 2, 3 or 4	Integrated Forestry Operations Approval (Schedule 10) Private Native Forestry Code of Practice (Table C)	Identify & manage risks	See for example Land Degradation Risk Mapping of NSW	OEH

Table A3.5: Rule set for Available Timber Resources (white cypress pine only)

Theme	Rule set Criteria	Reference	Action	Data	Custodian
Recruitment and Habitat Trees	All "Old Greys"* 5 trees per hectare of Old Grey and cypress recruitment trees	Private Native Forestry Code of Practice (Table D)	Exclude from total timber volumes – tree retention	Derived structural diversity Derived canopy cover	FCNSW
Stem Size	Stand basal areas less than 6 square metres per hectare	Integrated Forestry Operations Approval (Cl. 207, Cl. 198) Private Native Forestry Code of Practice (Table A)	Exclude from total timber volumes	Derived density and patch size Derived canopy cover	FCNSW
Disturbance - Fire	Any areas of mapped wildfire from 2005		Exclude from total timber volumes	Fire history	OEH
Previous Harvesting	Any previously harvested areas of cypress with stocking levels less than 80 percent	Private Native Forestry Code of Practice (Table B)	Exclude from current total timber volumes	Harvest history Derived Density & Patch Size	FCNSW

* an **Old Grey** is a late-mature/over-mature cypress tree that has regenerated before the 1890s, has bark that is bleached to a characteristic light grey colour, and is weathered to a smoother surface texture than is typical of younger trees.

Attachment 4 - Technical advisors and contributors

Technical advisors/contributors	Expertise
Associate Professor Cris Brack	Natural resource and forestry measurement and modelling
Rob de Fegely	Forest management and policy
Dr Mark Fenton	Socio-economic assessment
Professor Hugh Ford	Conservation biology
Dr John T Hunter	Ecology and botany
Dr Rod Kavanagh	Forest wildlife scientist
Dr Anne Kerle	Ecologist
Dr Frank Lemckert	Terrestrial wildlife ecology
Andrew Morton	Forest management and commercial opportunities
Colin Stucley	Bioenergy
Dr Russell Turner	Spatial analysis
Dr Julian Wall	Landscape ecology

Attachment 5 -List of submissions

Submissions from organisations		Submissions from individuals	
1.	Baradine Progress Association	1.	David Paull
2.	Central West Environment Council	2.	Heather Andrews
3.	Friends of the Pilliga	3.	Dr Helen Stevens
4.	Gunnedah Shire Council	4.	Hugh Ford
5.	Gunnedah Timbers Pty Ltd	5.	Michael Sweeney
6.	Hunter Environment Lobby Inc.	6.	Phyllis Setchell
7.	Institute of Foresters of Australia	7.	Tom Underwood
8.	Mudgee District Environment Group	**8.**	Wendy Hawes
9.	Namoi Catchment Management Authority		
10.	National Parks Association		
11.	Northern Inland Council for the Environment Inc.		
12.	NSW Apiarists' Association Inc.		
13.	NSW Farmers		
14.	NSW Forest Products Association		
15.	NTSCORP Ltd (Native Title Services Corporation)		
16.	Universal Composts Pty Ltd		
17.	Wilderness Society		

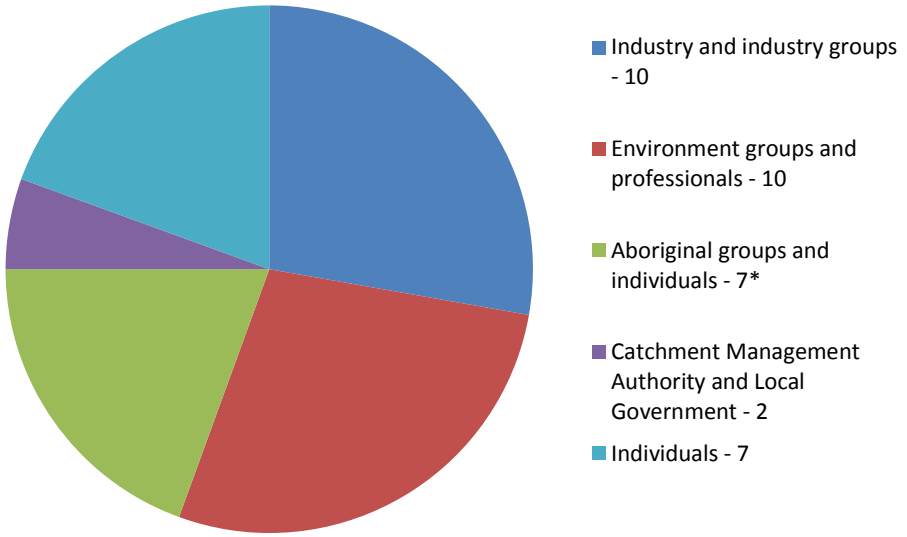
Note: The submissions listed above are available in full at www.nrc.nsw.gov.au. The NRC also received a further 11 submissions that were requested to remain confidential and have not been placed on the website.

Attachment 6 -Summary of stakeholder feedback

The NRC invited public submissions on the Terms of Reference to inform its review of active and adaptive management in the Brigalow and Nandewar State Conservation Areas. The NRC has also undertaken targeted consultation with relevant industry, Aboriginal, environmental and community groups. The NRC appreciates the time and effort that went into all submissions, and would like to thank all those who have contributed to the review so far. Information and views collected during this consultation have been incorporated into this summary.

Submissions analysis

The submissions process generated 36 formal submissions from industry representatives and groups, environment groups and professionals, individual community members, Aboriginal groups or individuals, Local Government and one Catchment Management Authority.



* Two of these submissions represent multiple Aboriginal groups

Figure A6.1: The 36 stakeholder submissions received by category

Submissions can be accessed via the NRC's website (unless requested to remain confidential): www.nrc.nsw.gov.au

Stakeholder feedback covered a variety of issues, and included arguments for or against active and adaptive management and specific active management options. Of the 36 submissions received, active and adaptive management was:

- Supported – 16
- Conditionally supported - for example using fire or grazing – 2
- Conditionally supported - but against any commercial thinning – 9
- Not supported in any form – 4
- Requested to be kept informed of the NRC review, no views expressed - 5

History and values of the State Conservation Areas

Submissions identified that the State Conservation Areas (Zone 3 of the broader Community Conservation Area) have diverse ecological characteristics, landscapes or vegetation communities. Stakeholders indicated that the State Conservation Areas should not be referred to as forests, and that they should be referred to as reserves of western woodland vegetation communities.

The State Conservation Areas were identified as currently supporting a range of values, such as:

- habitat for declining woodland bird species and a range of other flora and fauna, including large koala populations and threatened and near-threatened species such as the glossy black-cockatoo, brown treecreeper, turquoise parrot, barking owl, speckled warbler, hooded robin and diamond firetail, as well as pilliga mouse
- very high spiritual and cultural connection for Aboriginal people
- areas for Aboriginal people to collect bush tucker and medicine, and cultural camps. Cultural trading has also been practiced in some reserves, for example removal of timber for didgeridoos
- recreation, for example through wildflower tours, bird watching tours and bike tours and tourist attractions
- the north-west bee keeping industry, by providing pollen resources, a nursery for breeding and a sanctuary from chemical spraying in the surrounding agricultural landscape.

Eight submissions emphasised how the current landscape is very different to the likely pre-European landscape, and that past management has shaped the present values and ecological communities within the State Conservation Areas. For example, Aboriginal burning had a significant impact on the type of ecological communities present prior to European settlement, while clearing, grazing, silviculture, ironbark removal and fire management have shaped these areas following European settlement.

Some of these submissions suggested that previous forestry activities have diminished the present conservation value of some State Conservation Areas. For example, that ironbark and grassland ecological communities have now been replaced by more white cypress pine-dominated ecological communities. Further, some submissions presented anecdotal evidence that there is an overabundance of woody weed undergrowth (such as bulloak, box and wattle) in some parts of the State Conservation Areas that is impacting on key vegetation communities and fauna.

Some submissions recognised the socio-economic benefits derived from cypress forestry in Zone 4 areas of the Community Conservation Area, and some highlighted the importance of the local cypress pine timber industry for the community, particularly the towns Baradine and Gwabegar.

Management objectives

The submissions discussed the current intent and objectives of the Brigalow and Nandewar Community Conservation Areas in the context of active and adaptive management.

Some suggested that the original vision of managing the Community Conservation Areas as a single landscape via common active management principles is compatible with active and adaptive management of the State Conservation Areas. For instance, the Community Conservation

Advisory Committees were based on a strategic adaptive management model, though adaptive management hasn't been implemented in practice.

Others indicated that specific active management options are incompatible with current State Conservation Area objectives, in particular ecological thinning with commercial use of residues. For example, some submissions stated that the ecologically sustainable development principles in this context relate to mining and visitor infrastructure, not to commercial forestry gains.

Some submissions generally promoted the need for clear management goals and objectives for the State Conservation Areas. These submissions stated that there is limited evidence about what the forest was initially like, desired management outcomes must be identified, along with a strategy to achieve them. Some stakeholders suggested that development and finalisation of Threatened Species Action Plans or plans of management may provide the best indication of conservation objectives and proposed management actions. As such, stakeholders felt it is important that plans of management be finalised as a priority of Government. Any management actions should be consistent with the aims, objects and actions contained within these draft plans.

Other submissions proposed management objectives that could be used to guide an active and adaptive management strategy; for example:

- create and maintain a sustainable forest structure that increases habitat value
- prevent dense cypress or bulloak regrowth, and enhance habitats that have been reduced since European settlement
- enhance large crowned and hollow bearing trees and promote potential recruits to enhance ecological values by removing competition from neighbouring trees
- maintain forest structure and species diversity with the long-term aim of achieving an old growth mixed age stand
- protect and enhance nectar sites, areas around creeks, particularly nesting sites for barking bwls, and areas with large eucalypts or *Angophora*.

Feedback on active and adaptive management

Support for active and adaptive management

Over half the submissions supported active and adaptive management in the State Conservation Areas, although some of these stakeholders did not support specific active management interventions such as mechanical ecological thinning.

Stakeholders in support of active and adaptive management suggested that although active management in reserves has not been implemented well in the past, current reserve management practices also don't appear to be working and the ecological function of the reserves could be improved through active management.

Stakeholders identified stand structure (the size and spacing of trees) as a primary determinant of flora and fauna conservation values, and that this is being limited in some State Conservation Areas by areas of current woody weed undergrowth. It is suggested that these areas will take a long time to return to more desired state without active intervention, but that any active management needs to be targeted towards specific conservation outcomes otherwise it will further set-back the natural transition to better forest structure.

Other submissions suggested that the benefits of active and adaptive management would include better management of the risks of wildfire through a cross-tenure review of grazing and prescribed burning practices for fuel hazard reduction, and the opportunity to make management processes, controls and ecological considerations more consistent across reserves and private land.

One stakeholder suggested that Strategic Active Management be used to manage reserves in the Pilliga. They proposed a four step process of setting the desired future state; exploring management options; implementation of chosen optionsfollowed by evaluation and learning,. Examples of this approach include in the Macquarie Marshes and Kruger National Park, South Africa and it is suggested that this approach would require a rethink of current practices by all land managers.

If carried out correctly, submissions suggested that active management could:

- improve ecological outcomes
- provide a landscape approach to reserve management
- preserve Aboriginal cultural sites
- provide Aboriginal employment to carry out fencing, bushfire training and cultural values assessment and management
- allow communities to have genuine input into how sites are managed
- recognise that what works well in one area might not work in another.

Some submissions cautioned that while active and adaptive management is likely to be beneficial, it would require a change in culture and current practices by the National Parks and Wildlife Service. It would also require support from the community, environmental and industry groups.

It was also suggested that external oversight of any active and adaptive management practices would be required from an independent body, such as the Environment Protection Authority. There was concern that the Terms of Reference did not provide information on who will monitor and manage active and adaptive management, and who has the rights to any economic returns from active and adaptive management (for example from the commercial use of ecological thinning).

Some submissions also cautioned that the Pilliga is a difficult landscape to manage, with natural features making some areas difficult to access via track and trail networks.

Arguments against a new active and adaptive management strategy

Four submissions opposed a new active and adaptive management regime. Some of these suggested that an option to allow natural processes to proceed should be considered. Others felt that the State Conservation Areas are unique and are currently well managed by National Parks and Wildlife Service, or supported the conversion of the State Conservation Areas to National Park tenures.

There were also some stakeholder concerns raised about the impact of active and adaptive management on future mineral extraction or on native title rights such as access and the use of resources for hunting, fishing and gathering. Concerns about the potential for damage to Aboriginal cultural sites were also raised.

Requests for more information

Some stakeholders called for further explanation of the term 'active and adaptive management'. In response, the NRC has put a paper titled "Definition of key concepts in terms of reference" on our website to explain and provide references for the key terms being used. Further, the definition of 'ecological sustainable development' is currently being reviewed under proposed changes to the NSW Planning Act.

Some submissions also identified that more baseline data on the current condition of the State Conservation Areas is required before any decisions on active and adaptive management are made. Also, that further baseline environmental information is needed prior to implementation of a particular landuse regime so that the results of active management can be tracked.

Feedback on Aboriginal involvement in active and adaptive management

Aboriginal stakeholders emphasised their strong spiritual and cultural connection with the State Conservation Areas and the importance of Traditional Owners and native title groups having meaningful management opportunities in these reserves. This could include the use of Traditional Owner knowledge in reserve planning, operations, accountability and performance tracking. Submissions highlighted the need to include Traditional Owners in any economic development opportunities, and suggested Aboriginal work opportunities should be extended and involve dedicated Aboriginal land management positions that respect Aboriginal cultural heritage sites and practices.

Stakeholders emphasised the importance of protecting the vegetation and cultural values in State Conservation Areas. Submissions suggested that cultural values need to be identified via a full cultural values assessment before active and adaptive on ground management can occur. This could show what cultural sites are present before any on ground work is done, ensuring sites are protected. Management of cultural values needs to be properly resourced as Aboriginal groups do not have the resources or the infrastructure to do this work. Some stakeholders viewed some local council consultation methods as unsatisfactory, specifically noting the practice of engaging people from outside the local area to carry out cultural heritage surveys, assessments and environmental surveys. Feedback suggested that cultural values assessments should be done by appropriately trained local Aboriginal people and should consult with the local Aboriginal community, Local Aboriginal Land Councils and native title groups.

Submissions emphasised that State Conservation Areas provide Aboriginal people with opportunities to collect bush tucker, bush medicine and hold cultural activities such as culture camps. State Conservation Areas can provide educational experiences to local Aboriginal people as well as tourists visiting the region. Public acknowledgement of Traditional Owners roles in relation to the State Conservation Areas is important to stakeholders. Also raised is the need for funding and support for Aboriginal people to manage their land and that Aboriginal community consultation on cultural values by Forestry Corporation was seen by some stakeholders as inadequate.

Feedback on community engagement

A number of stakeholders indicated that the development of an active and adaptive management strategy should be based on community input via an effective and well-resourced community advisory committee system, as well as an accountable public review mechanism.

Some submissions highlighted that the Brigalow Belt and Nandewar Community Conservation Advisory Committees ceased being funded in 2012 and are no longer involved in developing plans of management. Stakeholders called for these groups to be reconstituted and funded as one strategic consultative group, representing industry, community and agencies. Other stakeholders suggested the existing Regional Advisory Committees under the National Parks and Wildlife Act as a more appropriate, less duplicative mechanism for community involvement in reserve management planning.

Feedback regarding ecological thinning

Support for ecological thinning and suggestions for implementation

The majority of submissions supported ecological thinning, with some providing caveats or conditions for their support. Reasons given for this include to enhance forest structure and function or to support the regional timber industry. Ecological thinning is seen by some to provide an alternative to hazard reduction burning. Stakeholders indicated that cypress pine is currently being actively managed for conservation outcomes in the Gilgandra Flora Reserve.

A number of submissions suggested that ecological thinning programs should be undertaken by locally trained people with a view to creating a self-sustaining system, where further dense regrowth is suppressed by mature trees.

The program should be based on science, and should take into account environmental considerations such as carbon sequestration and storage and embodied energy of construction materials. It was suggested that a controlled thinning regime similar to an Invasive Native Species Property Vegetation Plan may be appropriate in areas where cypress is deemed excessively dense, although other stakeholders specifically cautioned against transferring the native vegetation framework to management of the parks estate.

Stakeholders emphasised the need for sufficient funding to cover the adaptive management cycle of planning, implementation, monitoring and evaluation. Submissions also indicated concern over the supervision of any ecological thinning, and some proposed that any ecological thinning should be managed by the National Parks and Wildlife Service, not State Forests, as it is for conservation and not silvicultural purposes.

Stakeholders identified that there would be opportunities for Aboriginal people to be involved in thinning programs, including in the monitoring of impacts. For example, in Queensland, Aboriginal people are employed to monitor land clearing. They walked along as the clearing was being carried out to ensure sites were identified and not disturbed. Men and women need to be present at all times during work that could disturb sites as the cultural sites for men and women are different and require a strong governance framework.

Stakeholders indicated that some coarse woody debris from thinning should be retained where possible for ecological benefits, provided it doesn't lead to increased fire risk. Thinning residue that would significantly increase the fire risk should be removed.

Submissions called for various alternative methods of thinning to be considered. For example, brushcutters instead of large scale mechanical methods. Some stakeholders had concerns about the environmental impacts of mechanical thinning.

Arguments against ecological thinning

Four submissions argued against the use of ecological thinning as an active management option. These submissions stated that threatened ecological communities and important habitat features are rare in the general landscape (such as large old trees, mixed age forest structure, known fauna food trees) and must be protected from disturbance by silviculture, thinning and logging practices.

Potential disturbances and negative impacts were cited as being increased noise, lights, human activity, vehicle movements, roads, weed and feral animal incursions, possible oil and petrol spills and impact on recreation activities such as bushwalking and birdwatching. Stakeholders felt that the risk of habitat destruction by timber harvesting activities cannot be justified in an area reserved for conservation outcomes.

Some of these submissions suggested thinning is more suitable for the Zone 4 State Forest areas where the benefit of reducing regrowth, ecological outcomes and commercial outcomes can be more compatible.

Others indicated that active management of cypress regrowth has not been identified as the highest priority management activity in the region, and more resources should be given to threatened species management in the region instead.

Support for commercial outcomes from ecological thinning

Within the stakeholders in favour of ecological thinning as a management tool, there was mixed feedback about whether it was then appropriate to derive commercial benefits from ecological thinning residues.

Sixteen submissions supported the commercial use of ecological thinning residues in order to undertake active and adaptive management in a cost effective manner, and to gain social and economic benefits for local communities and industries.

A number of these stakeholders expressed concern that strategic active and adaptive management, including ecological thinning programs, will be prohibitively expensive. Allowing some cost-recovery through commercial use of residues is more likely to lead to an economically sustainable management program with a greater chance of achieving ecological outcomes.

Other stakeholders felt that any commercial value of thinning cypress forests in State Conservation Areas should go back to the community where the forest is located. Stakeholders raised concerns about the viability of the mill in Baradine under current timber supply, and indicated that Baradine and Gwabegar have been impacted by previous timber industry contraction and would benefit from the employment opportunities provided by thinning programs.

Stakeholders indicated that alternative markets for non-commercial thinning will need to be developed in order to obtain any social and economic benefits. Submissions identified two previous projects focused on the use of residues for bioenergy and fuel briquettes, and that there may be an opportunity to investigate other high value niche products such as essential oils from the timber resource.

Arguments against commercial outcomes from ecological thinning

Conversely, nine other stakeholders felt that while ecological thinning should be implemented or trialled, any commercial use of thinning residues should not be permitted. Reasons given for this view include inconsistency with the current legislation, agreements and management plans. It was also suggested that allowing commercial access to ecological thinning residues may undermine the

conservation outcomes being sought, or may set a precedent for increased economic use of reserve areas, particularly for commercial forestry.

Some of these stakeholders expressed concerns that a shortage of commercial timber is driving a reversal of conservation decisions. Stakeholders indicated that the Community Conservation Area reserve system was developed after a long period of public consultation and included recompense to the timber industry and generous offers of jobs to displaced workers. The decision has been accepted by the community and it would be "stirring up a hornet's nest" to revisit the conclusions and change decisions made to allow commercial forestry activities.

Requests for more information

Other stakeholders sought more clarity about the commercial opportunities that may arise from ecological thinning, particularly the likely overlap between commercially and ecologically valuable trees.

Feedback on fire management

Fifteen stakeholders discussed their views on the value and role of fire in managing these forests. Amongst these stakeholders, support for the use of fire management as part of an active and adaptive management program was common, but a number of stakeholders also raised concerns about the high risks posed by fire in this region.

Specific stakeholder views included support for low intensity mosaic burning in appropriate seasons which was suggested as the least cost, lowest risk option for active management. Some stakeholders felt the current fire management regime could be improved by the use of more frequent mild fires – cool, seasonal mosaic burning to remove cypress seedlings. For example, submissions from apiarists indicated that they prefer earlier, and cooler, prescribed fire burning, as this has less impact on tree physiology such as flowering.

Stakeholders that expressed concerns about the risks posed by fire indicated that fire management regimes should be designed to reduce hollow loss as far as possible and that the risks of fires getting out of control are extremely high.

Submissions stated that prior to European settlement Aboriginal burning regimes had helped maintain habitat for native fauna. Stakeholders indicated that some Aboriginal groups have been involved in active burning, but it can be difficult to find people who know how to carry out cultural burning. Cultural burning skills need to be learnt, for example via the Firesticks Program. Some Aboriginal stakeholders did not support active fire management on grounds that it is high risk.

Feedback on grazing

Stakeholder feedback on grazing as an active management intervention was mixed. Some felt that if managed well grazing (as well as fire) can be an effective tool for enhancing biodiversity in cypress. Grazing was proposed as an alternative or as a complement to burning and thinning to restore ecosystem function and to enhance natural values. Other stakeholders felt that the re-introduction of grazing by hard-hooved domestic stock was not appropriate due to the potential for ecological damage in sensitive areas like watercourses and wetlands, erodible soils and areas supporting rare and threatened species.

Alternative management options to be explored

Submissions suggested a range of additional management actions that could be considered including:

- re-introduction of the dingo, which may result in a reduction in the numbers of foxes and cats, allowing native herbivores to re-establish. These herbivores may eat cypress seedlings, resulting in control of regeneration.
- small scale experimental re-introduction of other species lost from this ecosystem such as bettongs, possibly involving fencing blocks to exclude pest species such as foxes and cats.
- spreading quandongs, a root parasite, in areas of dense regrowth to weaken and eventually carry out the thinning process (this could also support an industry as they supply food and oil kernels, and may also have some Indigenous cultural benefits)
- a bounty on pest animals such as foxes and cats (this would need to be policed properly).

Off-park alternatives

Some stakeholders suggested different methods be tested on and off the State Conservation Areas, for instance:

- on-park testing and refinement of existing non-commercial adaptive management tools (for example, fire)
- off-park testing of adaptive management (ecological thinning) in equivalent non- State Conservation Areas areas (for example, Zone 4 State Forests) - any ecological thinning trials should be conducted in ecologically equivalent State Forest areas in preference to within reserve areas such as State Conservation Areas.

If these off-park adaptive management trials are run, stakeholders suggested they would need:

- independent scientific oversight (for example, a reference panel)
- clearly stated objectives and outcomes (for example, increase species number or diversity)
- control sites (could be a joint trial – active and adaptive management on State Forest tenure and control sites in the State Conservation Areas)
- a transparent process where all information and decisions are made public
- a stakeholder committee (including timber industry) to address concerns about the process.

Other issues

Stakeholders raised other issues during the consultation, including that the growth of coal seam gas may have an economic impact on the timber industry in state forests or has the potential to cause environmental damage. Gas development is an outstanding issue in the Pilliga and should be part of the context of the Terms of Reference. Barriers to tourism were also raised as an issue in the State Conservation Areas.

Attachment 7 -Summary of stakeholder engagement

Organisations consulted	
Government agencies / State owned corporations	
Department of Primary Industries	NSW Rural Fire Service
Department of Premier and Cabinet	Office of Communities – Aboriginal Affairs
Environment Protection Authority	Office of Environment and Heritage (including National Parks and Wildlife Service)
Forestry Corporation of NSW	
Local Government	
Gunnedah Shire Council	Narrabri Shire Council
Environment groups	
Central West Environment Council	National Parks Association
Central West NRM Group	National Parks & Wildlife Advisory Council
Dubbo Field Naturalists	National Parks Northern Tablelands Regional Advisory Committee and Northern Plains Regional Advisory Committee
Friends of the Pilliga	Nature Conservation Council
Gilgandra Native Flora Society	
Industry associations / representatives	
Andrews V & HD (Jack) Haulage Pty Ltd	Institute of Foresters of Australia – NSW division
Baradine Progress Association	NSW Apiarists' Association Inc.
Baradine Sawmilling Co	NSW Farmers
Grants Sawmilling Co	NSW Forests Products Association
Gunnedah Timbers Pty Ltd	Universal Composts
Hyde Haulage Pty Ltd	
Aboriginal groups	
Baradine Local Aboriginal Land Council	Red Chief Local Aboriginal Land Council
Gawambaraay Pilliga Co-Management Committee	Tubba-Gah Applicant and Tubba-Gah Traditional Owners
Gilgandra Local Aboriginal Land Council	Wee Waa Local Aboriginal Land Council
NSW Aboriginal Land Council	Weilwan Local Aboriginal Land Council
Pilliga Local Aboriginal Land Council	

Attachment 8 -Community Conservation Area visits by NRC

Community Conservation Area visits	
State Conservation Areas (Community Conservation Areas Zone 3)	
Beni	Killarney
Biddon	Gwydir River
Bingara	Merriwindi
Bobbiwaa	Pilliga
Cobbora	Pilliga East
Durridgere	Pilliga West
Goodiman	Trinkey
Goonoowigal	Warialda
Goonoo	Wondoba
State Forests (Community Conservation Area Zone 4)	
Jacks Creek	Pilliga East
Euligal	
Merriwindi	
National Parks (Community Conservation Area Zone 1)	
Timmallallie	Yarragin
Pilliga	
Nature Reserves	
Pilliga	
Aboriginal Areas (Community Conservation Area Zone 2)	
Dandry Gorge (situated within the Pilliga Nature Reserve)	
Willala	

Attachment 9 - Relevant legislation

Legislation	Brigalow Nandewar Community Conservation Area	Relevance to active management of cypress forests in State Conservation Areas
Brigalow Nandewar Community Conservation Area Act 2005 (NSW)	▪ Reserves land under the *National Parks and Wildlife Act 1974* (Cth) and the *Forestry Act 1916* (NSW) (replaced by the *Forestry Act 2012*) in the Brigalow Nandewar Area to create a Community Conservation Area (Part 2) ▪ Establishes a Community Conservation Council and Community Conservation Advisory Committees (Part 3) ▪ Requires a Community Conservation Area Agreement to be developed and sets out the requirements for that Agreement (Part 4)	▪ Key legislation governing State Conservation Areas in the Brigalow Nandewar region
Environmental Planning and Assessment Act 1979 (EPA Act) (NSW)	▪ Encourages the protection of the environment, including threatened species, populations and ecological communities (s 5(a)(v111)) ▪ Requires assessment and mitigation of environmental impacts for certain categories of development that require development consent (Part 4) ▪ Requires assessment and mitigation of environmental impacts where activities are carried out by a public authority or require government approval other than development consent, and are likely to significantly affect the environment (Part 5)	▪ Requires the likely environmental impacts of active and adaptive management to be assessed (Part 5) ▪ In October 2013, the Government introduced the *Planning Bill 2013* into NSW Parliament to replace current planning legislation. The Bill proposed significant reforms to the planning framework in NSW ▪ Following significant amendments to the Bill by the Legislative Council, debate on the Bill was deferred by the Legislative Assembly on 28 November 2013
Environmental Protection and Biodiversity Conservation Act 1999 (Cth)	▪ Establishes matters of national environmental significance (Part 3) ▪ Requires Australian Government assessment and approval of actions likely to have significant impacts on matters of national environmental significance (Part 3). This includes an	▪ The NSW and Australian Governments are taking steps to implement a 'one-stop shop' for environmental assessments and approvals in NSW[1] ▪ Under the proposed framework, all approvals under NSW legislation for active and adaptive management can

[1] COAG Communique, 13 December 2013.

Legislation	Brigalow Nandewar Community Conservation Area	Relevance to active management of cypress forests in State Conservation Areas
	action that is likely to have a significant impact on: - a National Heritage place (declared under the Act) - Ramsar wetlands - a listed threatened species or endangered ecological community - listed migratory species - a water resource and involves coal seam gas development or large coal mining development ▪ Provides for Commonwealth assessment of actions (Part 8) and approval of actions (Part 9) likely to have significant impacts on matters of national environmental significance	be accredited under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cth) and NSW will become responsible for assessing projects for the purposes of that Act
Fisheries Management Act 1994 (NSW)	▪ Regulates fisheries in NSW ▪ Lists endangered fish species, aquatic invertebrates and ecological communities (Schedule 4) ▪ Provides for conservation and planning in relation to threatened fish species and establishes a licensing scheme (Part 7A)	▪ Threatened fish species may be present in State Conservation Areas. Many areas in the State Conservation Areas also contain the aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River, which is listed as endangered under the Act
Forestry Act 2012 (NSW)	▪ Establishes the Forestry Corporation of NSW as a State-owned Corporation (Part 2) ▪ Provides for the dedication and use of State Forests and Crown-timber land for forestry (Part 3) ▪ Establishes a licensing scheme to regulate taking of timber from Crown land (Part 4) ▪ Provides for forest agreements (Part 5A) and integrated forest operations approvals (IFOA) (Part 5B) ▪ Provides for review of NSW Forestry Corporation's native	▪ Not applicable to State Conservation Areas. Applies to the State Forests Community Conservation Area Zone 4 lands in the Brigalow Nandewar region

Legislation	Brigalow Nandewar Community Conservation Area	Relevance to active management of cypress forests in State Conservation Areas
	timber harvest and haulage costs every three years, and the review report to be provided to IPART (Part 8)	
Heritage Act 1977 (NSW)	▪ Establishes the Heritage Council and the State Heritage Register (Part 2) ▪ Requires Heritage Council or local government approval for activities (including damaging or removing trees) that may affect items listed on the State Heritage Register or that are covered by an interim heritage order (Part 4) ▪ Provides for making of orders to control and restrict harm to heritage items (Part 6) ▪ Requires a government agency to keep a register of the environmental heritage that it owns/ controls (Part 8)	▪ State Conservation Areas contain items of historic heritage. Active and adaptive management may require approval under the Act
National Parks and Wildlife Act 1974 (NSW)	▪ Provides for reservation of land in different categories including State Conservation Areas (Part 1) ▪ Requires plans of management to be prepared for reserves and to be given effect to by the Director General of the National Parks and Wildlife Service. Prohibits operations from being undertaken in national parks and reserves except in accordance with the management plan (Part 5) ▪ Prohibits damage to Aboriginal cultural heritage and establishes a permit system (Part 6) ▪ Prohibits damage to threatened fauna and flora species (Part 8A) ▪ Establishes a licensing regime in respect of fauna, native plants and threatened species (Part 9) ▪ Prohibits damage to land reserved under the Act: s 156A (Part 14)	▪ Key legislation governing State Conservation Areas in the Brigalow Nandewar region. Activities in State Conservation Areas need to be consistent with the objects of the Act and management principles for State Conservation Areas ▪ State Conservation Areas contain Aboriginal cultural heritage. Active and adaptive management may require an Aboriginal Heritage Impact Permit ▪ Under proposed cultural heritage reforms Aboriginal cultural heritage would be regulated under new standalone legislation

Legislation	Brigalow Nandewar Community Conservation Area	Relevance to active management of cypress forests in State Conservation Areas
Native Vegetation Act 2003 (NSW) *Native Vegetation Regulations 2013* (NSW)	▪ Provides definitions of key terms (Part 2) such as native vegetation ▪ Regulates how native vegetation, including white cypress, is managed on private land. Prohibits broadscale clearing of native vegetation unless it maintains or improves environmental outcomes and establishes a consent process for native vegetation management via property vegetation plans (PVPs) (Parts 3 and 4)	▪ Not applicable to State Conservation Areas ▪ The NSW Government intends to review the *Native Vegetation Act 2003* (NSW) ▪ The *Native Vegetation Regulation 2013* has been amended to allow landholders and managers on private land to clear invasive native species or thin native vegetation (including white cypress pine) as a *routine agricultural management activity*. This is instead of seeking approval under a Property Vegetation Plan. The Government released draft Ministerial orders and landholder guidelines for public consultation in March 2014 ▪ Under the Regulation, private native forestry has been expanded to include Crown land, allowing landholders with these types of Crown leases to obtain a Private Native Forestry Property Vegetation Plan
Protection of the Environment Administration Act 1991 (NSW)	▪ Establishes the Environment Protection Authority (Part 2) and its responsibilities (Part 4)	▪ The principles of ecologically sustainable development set out in section 6(2) must be applied when making decisions regarding active and adaptive management in State Conservation Areas
Protection of the Environment Operations (General) Regulation 2009 (NSW)	▪ The Regulation is made under the *Protection of Environment Operations Act 1997*, which aims to protect, restore and enhance the quality of the environment in NSW	▪ The Regulation allow certain categories of native forest biomass to be used for electricity generation, ie: biomass sourced from: - trees cleared under a Property Vegetation Plan - trees thinned or cleared under a private native forestry Property Vegetation Plan - trees cleared under an Integrated Forestry

Legislation	Brigalow Nandewar Community Conservation Area	Relevance to active management of cypress forests in State Conservation Areas
		Operations Approval - sawdust, sawmill waste and other waste from the processing of wooden products - plantations ▪ Amendments to the Regulation would be required to permit residues as a result of ecological thinning in State Conservation Areas to be used for electricity generation
Rural Fires Act 1997 (NSW)	▪ Establishes the NSW Rural Fire Service and provides for the establishment of rural fire brigades (Part 2) ▪ Establishes Bush Fire Coordinating Committees. Committees must prepare bushfire management plans which set out schemes for the reduction of bushfire hazards (Part 3) ▪ Imposes a duty on public authorities to prevent occurrence of bushfires and minimise danger of spread on their land (Part 4)	▪ Grazing and thinning active management may be appropriate methods of bushfire control and may be permitted in certain circumstances: - section 63 imposes a duty on the Office of Environment and Heritage to take notified steps (if any) and any other practicable steps to prevent the occurrence and minimise the spread of bushfires on land under its management - section 100C(4) also provides for bushfire hazard reduction to be carried out on land despite requirements for approval under the *Native Vegetation Act 2003*, *Threatened Species Act 1995* and/or the *National Parks and Wildlife Act 1974* ▪ Grazing and thinning active management may even be required to manage bushfire risk in certain circumstances without the requirement for approvals under the *National Parks and Wildlife Act 1974* or other Acts. However this is an exception rather than the norm
Threatened Species Conservation Act 1995 (NSW)	▪ Provides for the listing of species, populations and ecological communities and threatening processes (Part 2) ▪ Provides for identification and declaration of critical habitat	▪ There are recorded threatened species in State Conservation Areas ▪ Active and adaptive management needs to be consistent

Legislation	Brigalow Nandewar Community Conservation Area	Relevance to active management of cypress forests in State Conservation Areas
	(Part 3) ▪ Provides for preparation of recovery plans (Part 4) and threat abatement plans (Part 5) ▪ Provides for issue of licences to harm threatened species (Part 6)	with the biodiversity conservation objects of the Act

Attachment 10 - NSW Vegetation Classification and Assessment Type

Classification and Assessment of NSW Vegetation (Benson, Richards, Waller, & Allen, 2010).

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	17	-	None	Leard (0-10%), Pilliga (0-10%), Pilliga West (0-10%)
480	Black Cypress Pine - ironbark -/+ Narrow-leaved Wattle low open forest mainly on Narrabeen Sandstone in the Upper Hunter region of the Sydney Basin Bioregion	90	-	None	Durridgere (0-10%)
417	Black Cypress Pine - Narrow-leaved Ironbark - red gum +/- White Bloodwood shrubby open forest on hills of the southern Pilliga, Coonabarabran and Garawilla regions, BBS Bioregion	85	-	None	Trinkey (0-10%), Wondoba (0-10%)
504	Black Cypress Pine - Rough-barked Apple - stringybark shrubby open forest of the Nandewar and western New England Tablelands Bioregions	50	-	None	Goonoowigal (>50%), Tingha Plateau (>50%)
112	Black Tea-tree - River Oak - Wilga riparian low forest/shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion	33	-	None	Bingara (0-10%), Bobbiwaa (0-10%), Warialda (0-10%)
509	Blakely's Red Gum - White Cypress Pine - Rough-barked Apple grassy open forest of drainage lines of the northern Nandewar and New England Tablelands Bioregions	25	•	Listed TSC Act (Endangered) Listed EPBC Act (Critically Endangered)	Goonoowigal (0-10%), Gwydir River (0-10%)
423	Blue-leaved Ironbark - Black Cypress Pine - Rough-barked Apple woodland mainly in the east Pilliga forests, BBS bioregion	94	-	None	Pilliga East (0-10%)
467	Blue-leaved Ironbark - Black Cypress Pine shrubby sandstone open forest in the southern BBS Bioregion (including Goonoo)	83	-	None	Biddon (0-10%), Cobbora (0-10%), Durridgere (0-10%) Goodiman (0-10%), Goonoo (>50%)
35	Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion	10	-	Listed TSC Act (Endangered) Listed EPBC Act (Endangered)	Leard (0-10%), Pilliga (0-10%), Pilliga West (0-10%)

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
445	Brigalow viney scrub open forest on loamy soils in low hill landscapes in the northern BBS Bioregion NSW	20	-	Listed TSC Act (Endangered) Listed EPBC Act (Endangered)	Bingara (0-10%)
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	89	-	None	Biddon (0-10%), Goonoo (0-10%), Pilliga (0-10%), Pilliga East (0-10%)
411	Buloke[2] - White Cypress Pine woodland on outwash plains in the Pilliga Scrub and Narrabri regions, BBS bioregion	75	•	None	Bullawa Creek (0-10%), Killarney (20-50%) Pilliga (0-10%),
428	Carbeen - White Cypress Pine - Curracabah - White Box tall woodland on sand in the Narrabri - Warialda region of the Brigalow Belt South Bioregion	50	•	Listed TSC Act (Endangered)	Bobbiwaa (0-10%), Killarney (0-10%)
427	Cypress pine - Tumbledown Red Gum low open woodland to grassland on rocky benches, mainly in the Nandewar Bioregion	93	•	None	Leard (0-10%)
409	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, BBS Bioregion	83	•	None	Merriwindi (20-50%), Pilliga (0-10%), Pilliga East (20-50%)
148	Dirty Gum - Buloke - White Cypress Pine - ironbark shrubby woodland on deep sandy soils in the Liverpool Plains region of the BBS Bioregion	50	•	None	Trinkey (0-10%)
206	Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plain and BBS Bioregions	50	•	None	Pilliga West (0-10%)
408	Dirty Gum (Baradine Gum) - Black Cypress Pine - White Bloodwood shrubby woodland on of the Pilliga forests and surrounding region	86	-	None	Bullawa Creek (0-10%), Pilliga East (0-10%), Killarney (0-10%)
471	Dwyers Red Gum - Black Cypress Pine - ironbark low woodland on sandstone hillcrests in the Dubbo - Gilgandra region, south-western BBS Bioregion	80	-	None	Goonoo (0-10%)
432	Dwyers Red Gum - Dirty (Baradine) Gum - cypress pine shrubby woodland of the Narrabri region of the BBS Bioregion	93	-	None	Killarney (0-10%)

2 *Allocasuarina luehmannii* (commonly known as buloke, bull-oak or bulloak)

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
424	Dwyers Red Gum heathy low open woodland on sandstone ridges in the Pilliga Scrub, BBS Bioregion	100	-	None	Pilliga East (0-10%)
415	Fringe Myrtle shrubland of the Pilliga Scrub	93	-	None	Pilliga (0-10%)
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South (including Pilliga) and Nandewar Bioregions	25	-	Listed TSC Act (Endangered)	Goonoo (0-10%)
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern BBS Bioeregion	77	-	None	Biddon (0-10%), Goonoo (0-10%), Pilliga (0-10%)
519	Heathy shrubland on granitic substrates in the Howell area in the New England Tablelands Bioregion	92	-	Listed TSC Act (Endangered)	Goonoowigal (0-10%), Gwydir River (0-10%), Tingha Plateau (0-10%)
477	Inland Scribbly Gum - Red Stringybark - Black Cypress Pine - Red Ironbark open forest on sandstone hills in the southern BBS and northern NSWSWS Bioregions	60	-	None	Durridgere (0-10%), Goodiman (0-10%)
379	Inland Scribbly Gum - White Bloodwood - Red Stringybark - Black Cypress Pine shrubby sandstone woodland mainly of the Warrumbungle NP - Pilliga region in the BBS Bioregion	80	-	None	Pilliga (0-10%)
147	Mock Olive - Wilga - Peach Bush - Carissa semi-evergreen vine thicket (dry rainforest) mainly on basalt soils in the Brigalow Belt South Bioregion	17	-	Listed TSC Act (Endangered) Listed EPBC Act (Endangered)	Bingara (10-20%)
430	Motherumbah - red gum - White Cypress Pine tall shrubland of the Narrabri to Warialda region, BBS bioregion	65	•	None	Bullawa Creek (0-10%)
482	Mugga Ironbark - Black Cypress Pine shrub/grass open forest of the upper Hunter Valley, mainly Sydney Basin Bioregion	80	-	None	Durridgere (0-10%)
528	Mugga Ironbark - Blakely's Red Gum open forest of the Nandewar and New England Tablelands Bioregions	44	-	Nominated NSW TSC Act	Bingara (0-10%)
470	Mugga Ironbark - Narrow-leaved Ironbark - Buloke - Black Cypress Pine shrub grass open forest in the Goonoo forests and surrounding region, southern BBS Bioregion	67	-	None	Beni (20-50%), Biddon (0-10%), Goonoo (10-20%)
402	Mugga Ironbark - White Cypress Pine - gum tall woodland on flats in the Pilliga forests and surrounding regions, BBS Bioregion	60	•	None	Pilliga (0-10%)

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
468	Narrow-leaved Ironbark - Black Cypress Pine +/- Blakely's Red Gum shrubby open forest on sandstone low hills in the southern BBS Bioregion (including Goonoo)	67	-	None	Beni (20-50%), Biddon (>50%), Goonoo (0-10%)
592	Narrow-leaved Ironbark - cypress pine - White Box shrubby open forest in the Brigalow Belt South and Nandewar Bioregions	48	•	None	Leard (10-20%)
459	Narrow-leaved Ironbark - cypress pine - White Box shrubby woodland in sedimentary hills of the Gunnedah region, BBS Bioregion	67	•	None	Wondoba (20-50%)
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north BBS Bioregion	73	•	None	Bobbiwaa (>50%), Killarney (20-50%), Merriwindi (>50%), Pilliga (>50%), Pilliga East (10-20%), Pilliga West (20-50%), Trinkey (20-50%)
373	Narrow-leaved Ironbark - White Cypress Pine -/+ Buloke tall open forest or woodland of the Warialda to Yetman region, BBS Bioregion	60	•	None	Killarney (20-50%)
479	Narrow-leaved Ironbark- Black Cypress Pine - stringybark +- Grey Gum +- Narrow-leaved Wattle shrubby open forest on sandstone hills in the southern BBS - Sydney Basin Bioregions	60	-	None	Durridgere (>50%), Goodiman (0-10%)
416	Pilliga "tank gilgai" wetland sedgeland rushland, BBS Bioregion	47	-	None	Pilliga (0-10%)
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	62	•	None	Biddon (0-10%), Bingara (0-10%), Killarney (0-10%), Merriwindi (10-20%), Pilliga (10-20%), Pilliga West (10-20%), Trinkey (0-10%)
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW	22	-	None	Bobbiwaa (0-10%), Killarney (0-10%)
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, BBS Bioregion	55	•	None	Pilliga (0-10%), Pilliga West (20-50%)

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
511	Queensland Bluegrass - Redleg Grass - Rats Tail Grass - spear grass - panic grass derived grassland of the Nandewar and BBS Bioregions	10000	-	None	Bingara (0-10%), Leard (0-10%), Tingha Plateau (0-10%), Woodsreef (0-10%)
473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern BBS Bioregion	70	•	None	Beni (20-50%), Biddon (0-10%), Cobbora (0-10%), Goonoo (10-20%)
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion	90	-	None	Goonoo (0-10%), Pilliga (0-10%), Pilliga East (0-10%), Pilliga West (0-10%), Trinkey (0-10%)
478	Red Ironbark - Black Cypress Pine - stringybark -/+ Narrow-leaved Wattle shrubby open forest on sandstone in the Gulgong - Mendooran region, southern BBS Bioregion	71	-	None	Durridgere (0-10%), Goodiman (20-50%)
404	Red Ironbark - White Bloodwood -/+ Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	91	-	None	Pilliga (0-10%)
440	Red Stringybark - Narrow-leaved Ironbark - Black Cypress Pine - hill red gum sandstone woodland of southern NSW BBS Bioregion	66	-	None	Adelyne (>50%), Cobbora (>50%), Durridgere (20-50%), Goodiman (20-50%), Goonoo (0-10%)
400	Riparian sedgeland rushland wetland of the Pilliga to Goonoo sandstone forests, Brigalow Belt South Bioregion	81	-	None	Pilliga (0-10%), Pilliga West (0-10%)
84	River Oak - Rough-barked Apple - red gum - box riparian tall woodland (wetland) of the Brigalow Belt South and Nandewar Bioregions	60	-	None	Woodreef (0-10%)
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar and Brigalow Belt South Bioregions	40	-	None	Bingara (0-10%), Bobbiwaa (0-10%)
538	Rough-barked Apple - Blakely's Red Gum open forest of the Nandewar and western New England Tablelands Bioregions	55	-	Listed EPBC Act (Critically Endangered) Listed TSC Act (Endangered)	Goonoowigal (0-10%), Tingha Plateau (0-10%)
481	Rough-barked Apple - Blakely's Red Gum - Narrow-leaved Stringybark +/- Grey Gum sandstone riparian grass fern open forest on in the southern BBS and Upper Hunter regions	72	-	None	Durridgere (0-10%)

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
401	Rough-barked Apple - red gum - cypress pine woodland on sandy flats, mainly in the Pilliga Scrub region	67	-	None	Merriwindi (0-10%), Pilliga East (0-10%), Trinkey (0-10%)
281	Rough-Barked Apple - red gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSWSWS and BBS Bioregions	33	-	Listed TSC Act (Endangered) Listed EPBC Act (Critically Endangered)	Adelyne (20-50%), Cobbora (0-10%), Goodiman (0-10%)
544	Rough-barked Apple -/+ cypress pine +/- Blakely's Red Gum riparian open forest / woodland of the Nandewar and New England Tableland Bioregions	35	•	Listed EPBC Act (Critically Endangered) Listed TSC Act (Endangered)	Goonoowigal (0-10%), Tingha Plateau (0-10%), Warialda (0-10%), Woodsreef (0-10%)
582	Sedgeland fens wetland of impeded drainage of the Nandewar and New England Tablelands Bioregions	60	-	Nominated NSW TSC Act	Gwydir River (0-10%)
598	Silver-leaved Ironbark - White Box - White Cypress Pine viney scrub woodland in the Nandewar and BBS Bioregions	36	•	None	Bingara (20-50%), Warialda (0-10%)
413	Silver-leaved Ironbark - White Cypress Pine - box dry shrub grass woodland of the Pilliga Scrub - Warialda region, BBS Bioregion	62	•	None	Bullawa Creek (<50%), Pilliga (0-10%)
594	Silver-leaved Ironbark - White Cypress Pine shrubby open forest of Brigalow Belt South and Nandewar Bioregions	47	•	None	Bingara (0-10%), Gwydir River (0-10%), Warialda (20-50%), Woodsreef (0-10%)
448	Smooth-barked Apple - Black Cypress Pine - Red Stringybark sandstone open forest in the Warialda to Arakoola region of the Brigalow Belt South Bioregion	83	-	None	Warialda (10-20%)
422	Smooth-barked Apple - cypress pine - Narrow-leaved Ironbark - White Bloodwood tall heathy woodland of the Pilliga forests to Warialda region, BBS Bioregion	71	•	None	Bobbiwaa (0-10%), Killarney (0-10%), Pilliga East (0-10%)
425	Spur-wing Wattle heath on sandstone substrates in the Goonoo - Pilliga forests, Brigalow Belt South Bioregion	90	-	None	Biddon (0-10%)
542	Stringybark - Rough-barked Apple - cypress pine shrubby open forest of the eastern Nandewar and western New England Tablelands Bioregions	48	•	None	Gwydir River (0-10%), Woodsreef (>50%)

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
410	Swamp Paper-bark very tall shrubland wetland on sodic soils in the Pilliga Scrub region	77	-	None	Pilliga (0-10%)
460	Tumbledown Gum - ironbark - Porcupine Grass hummock grassland / low woodland of the Mount Kaputar to Bingara region, Nandewar Bioregion	93	-	None	Bingara (0-10%)
461	Tumbledown Gum woodland on hills in the northern NSW South-western Slopes and southern BBS Bioregions	50	-	None	Goodiman (0-10%)
578	Tumbledown Red Gum - Black Cypress Pine - Caley's Ironbark shrubby open forest of the Nandewar and western New England Tablelands Bioregions	66	-	None	Goonoowigal (10-20%), Tingha Plateau (20-50%)
562	Tumbledown Red Gum - White Cypress Pine - Caley's Ironbark shrubby open forest of the Nandewar and western New England Tablelands Bioregions	63	•	None	Bingara (0-10%), Gwydir River (>50%), Warialda (0-10%)
372	Wattle low woodland/ tall shrubland on sandstone ridges in the northern NSW BBS Bioregion	80	-	None	Warialda (0-10%)
27	Weeping Myall open woodland of the Darling Riverine Plains and Brigalow Belt South Bioregions	14	-	Listed TSC Act (Endangered) Listed EPBC Act (Critically Endangered)	Bobbiwaa (0-10%),
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	22	•	Listed TSC Act (Endangered) Listed EPBC Act (Endangered)	Goonoo (0-10%)
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South and eastern Darling Riverine Plains Bioregions	25	-	None	Bobbiwaa (0-10%), Trinkey (0-10%)
431	White Bloodwood - Dirty Gum - cypress pine shrubby low woodland on sandy soils in the Narrabri to Warialda region, BBS Bioregion	83	•	None	Bobbiwaa (20-50%)
407	White Bloodwood - ironbark - Black Cypress Pine shrubby sandstone hill woodland of the southern Pilliga forests	86	-	None	Pilliga East (0-10%)
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	94	-	None	Pilliga East (0-10%)
457	White Bloodwood - Red Ironbark - Black Cypress Pine woodland on sandstone hills in the Garawilla - Liverpool Plains region, BBS Bioregion	70	-	None	Trinkey (10-20%)

Veg ID No	NSW Vegetation Classification and Assessment type	% extent remaining	White cypress pine type	Legal status	Mapped in State Conservation Areas
405	White Bloodwood - Red Ironbark - cypress pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions	86	•	None	Goonoo (0-10%), Pilliga (0-10%), Pilliga East (20-50%)
597	White Box - cypress pine - Silver-leaved Ironbark shrub grass open forest / woodland of the northern Brigalow Belt South and Nandewar Bioregions	43	•	None	Bingara (20-50%), Warialda (20-50%)
587	White Box - White Cypress Pine - Rough-barked Apple shrubby open forest in the Kaputar area of Brigalow Belt South and Nandewar Bioregions	79	•	None	Leard (0-10%)
435	White Box - White Cypress Pine shrub grass hills woodland in the BBS and Nandewar Bioregions	42	•	Listed TSC Act (Endangered) Listed EPBC Act (Critically Endangered)	Beni (0-10%), Trinkey (0-10%), Wondoba (>50%)
588	White Box - White Cypress Pine shrubby hills open forest mainly in the Nandewar Bioregion	33	•	None	Leard (>50%), Woodsreef (10-20%)
458	White Cypress Pine - Buloke - White Box shrubby open forest on hills in the Liverpool Plains - Dubbo region, BBS Bioregion	70	•	None	Goonoo (0-10%), Trinkey (20-50%)
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	75	•	None	Beni (20-50%), Biddon (20-50%), Cobbora (0-10%), Goonoo (10-20%)
564	White Cypress Pine - Silver-leaved Ironbark - Caley's Ironbark open forest of the central Nandewar and western New England Tablelands Bioregions	30	•	None	Bingara (0-10%), Gwydir River (0-10%), Tingha Plateau (0-10%)
418	White Cypress Pine - Silver-leaved Ironbark - Wilga shrub grass woodland of the Narrabri-Yetman region, BBS Bioregion	75	•	None	Bobbiwaa (10-20%)
547	Wild Quince - Mock Olive - Rusty Fig - Iamboto - Sweet Pittosporum dry rainforest of rocky and scree areas of the Nandewar and New England Tablelands Bioregions	80	-	Listed EPBC Act (Endangered) Listed TSC Act (Endangered)	Bingara (0-10%), Gwydir River (0-10%)
77	Yarran shrubland of the NSW central to northern slopes and plains	23	-	Nominated NSW TSC Act	Pilliga West (0-10%), Trinkey (0-10%)
421	Yellow Box - White Cypress Pine alluvial terrace flats grassy woodland in the Pilliga forests to Warialda region, BBS Bioregion	40	•	Listed TSC Act (Endangered) Listed EPBC Act (Critically Endangered)	Pilliga East (0-10%)

● = vegetation group contains white cypress pine
- = vegetation group does not contain white cypress pine

Attachment 11 - Threatened species

Threatened flora and fauna species in the Brigalow and Nandewar State Conservation Areas (NSW Office of Environment and Heritage, 2013b, 2014).

Common name	Scientific name	Conservation status	
		Listing TSC Act[A]	EPBC Act[B]
Flora			
Ausfeld's wattle	*Acacia ausfeldii*	V	-
Granite homoranthus	*Homoranthus prolixus*	V	V
Inverell cycad	*Macrozamia humilis*	E	-
Keith's zieria	*Zieria ingramii*	E	E
Leafless indigo	*Indigofera efoliata*	E	E
McKie's stringybark	*Eucalyptus mckieana*	V	V
Narrow macbarronii	*Goodenia macbarronii*	V	-
Native milkwort	*Polygala linariifolia*	E	-
Pine donkey orchid	*Diuris tricolor*	V	-
Rupp's Boronia	*Boronia ruppii*	E	-
Scant pomaderris	*Pomaderris queenslandica*	E	-
Spiny peppercress	*Lepidium aschersonii*	V	V
-	*Callistemon pungens*	-	V
-	*Cyperus conicus*	E	-
-	*Homoranthus darwinioides*	V	V
-	*Philotheca ericifolia* (formerly *Eriostemon ericifolius*)	-	V

Common name	Scientific name	Conservation status	
		Listing TSC Act[A]	EPBC Act[B]
-	*Rulingia procumbens*	V	V
-	*Tylophora linearis*	V	E
Fauna			
Burrowing bettong	*Bettongia lesueur lesueur*	X	X
Corben's long-eared bat	*Nyctophilus corbeni*	V	V
Eastern cave bat	*Vespadelus troughtoni*	V	-
Eastern pygmy-possum	*Cercartetus nanus*	V	-
Koala	*Phascolarctos cinereus*	V	V
Large-eared pied bat	*Chalinolobus dwyeri*	V	V
Little pied bat	*Chalinolobus picatus*	V	-
Pale-headed snake	*Hoplocephalus bitorquatus*	V	-
Pilliga mouse	*Pseudomys pilligaensis*	V	V
Rufous bettong	*Aepyprymnus rufescens*	V	-
Sloane's froglet	*Crinia sloanei*	V	-
Spotted-tailed quoll	*Dasyurus maculatus*	V	E
Squirrel glider	*Petaurus norfolcensis*	V	-
Stick nest rat	*Leporillus* spp.	X	-
Yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*	V	-
Birds			
Australasian bittern	*Botaurus poiciloptilus*	E	E
Australian brush-turkey (population	*Alectura lathami*	E	-

Common name	Scientific name	Conservation status	
		Listing TSC Act[A]	EPBC Act[B]
in the Nandewar and Brigalow Belt South Bioregions)			
Barking owl	*Ninox connivens*	V	-
Black breasted buzzard	*Hamirostra melanosternon*	V	-
Black-chinned honeyeater (eastern subspecies)	*Melithreptus gularis gularis*	V	-
Black falcon	*Falco subniger*	V	-
Black-necked stork	*Ephippiorhynchus asiaticus*	E	-
Brown treecreeper (eastern subspecies)	*Climacteris picumnus*	V	-
Bush stone-curlew	*Burhinus grallarius*	E	-
Diamond firetail	*Stagonopleura guttata*	V	-
Gilberts whistler	*Pachycephala inornata*	V	-
Glossy black-cockatoo	*Calyptorhynchus lathami*	V	-
Grey crowned babbler - eastern subspecies	*Pomatostomus temporalis temporalis*	V	-
Hooded robin (south-eastern form)	*Melanodryas cucullata cucullata*	V	-
Little eagle	*Hieraaetus morphnoides*	V	-
Little lorikeet	*Glossopsitta pusilla*	V	-
Malleefowl	*Leipoa ocellata*	E	V
Masked owl	*Tyto novaehollandiae*	V	-
Painted honeyeater	*Grantiella picta*	V	-
Powerful owl	*Ninox strenua*	V	-

Common name	Scientific name	Conservation status	
		Listing TSC Act[A]	EPBC Act[B]
Regent honeyeater	*Anthochaera phrygia*	E	E
Scarlet robin	*Petroica boodang*	V	-
Speckled warbler	*Chthonicola saggittatus*	V	-
Spotted harrier	*Circus assimilis*	V	-
Square-tailed kite	*Lophoictinia isura*	V	-
Swift parrot	*Lathamus discolor*	V	-
Turquoise parrot	*Neophema pulchella*	V	-
Varied sittella	*Daphoenositta chrysoptera*	V	-

A: *Threatened Species Conservation Act 1995* (NSW)
B: *Environment Protection and Biodiversity Act 1999* (Cth)

Key:
E - Endangered
V - Vulnerable
X - Presumed Extinct

Attachment 12 – Aboriginal cultural heritage and historic heritage sites

State Conservation Area	Number of AHIMS registered sites	Number of heritage items or places of historic heritage
Adelyne	0	No information
Beni	3	3
Biddon	42	3
Bingara	2	No information
Bobbiwaa	4	1
Bullawa Creek	5	0
Cobbora	0	0
Durridgere	19	2
Goodiman	0	0
Goonoo	97	10
Goonoowigal	1	No information
Gwydir River	5	No information
Killarney	1	0
Leard	0	1
Merriwindi	1	0
Pilliga	18	0
Pilliga East	12	4
Pilliga West	19	9
Tingha Plateau	0	No information
Trinkey	30	2
Warialda	1	4
Wondoba	15	3
Woodsreef	1	No information
Total	**276**	**42**

Attachment 13 - Mining titles in the State Conservation Areas

Mining titles in the State Conservation Areas (NSW Department of Trade and Investment, 2013).

State Conservation Areas	Coal title (exploring)	Coal application	Petroleum title (exploring)	Petroleum application	Mineral title (exploring)	Mineral application
Adelyne	1		1			
Beni				1		
Biddon			1			
Bingara			1	1	3	
Bobbiwaa			2			
Bullawa Creek	1		1			
Cobbora	1		1			
Durridgere	4 (1 active mine)		2		2	
Goodiman	2			1	1	
Goonoo	2		1	1	1	
Goonoowigal			1		1	
Gwydir River					1	
Killarney			1			
Leard	2		2			
Merriwindi			2			
Pilliga			1			
Pilliga East	1		1			
Pilliga West			2	1		
Tingha Plateau					7	
Trinkey			2			
Warialda			1		2	1
Wondoba	1		1			
Woodsreef						1
Total	**15**	**0**	**24**	**5**	**18**	**2**

Attachment 14 - Overview of landscape history

Overview of the landscape history of the Brigalow Nandewar region (Curby & Humphries, 2002; Environment Protection Agency, 2014; Forestry Commission of NSW, 1987; Natural Resources Commission, 2010; Rolls, 1981).

Date	Event
Pre-1750	▪ Prior to European settlement, Aboriginal fire management was used in the region to support hunting.
1820s – 1860s	▪ Explorer John Oxley travels through the region and returns to Sydney in 1818 praising the virtues of the land for agriculture. ▪ European settlers begin arriving in the area, grazing licences issued & small farms are established in 1830. ▪ Introduction of rabbits in 1859.
1870s	▪ Changes in the condition of the land are already being observed by early land holders and travellers. ▪ First forest reserves placed over abandoned Crown holdings in 1876. ▪ Drought-induced loss of livestock (and therefore reduced grazing pressure) in mid-1870s. ▪ First forest ranger appointed and cutting diameter limit of 60cm introduced for white cypress pine in 1877. ▪ Drought breaking rains of 1878-1885.
1880s	▪ Cropping expanded dramatically leading to widespread clearing of forests and other native vegetation. Approximately 70 percent of original vegetation has now been cleared, with preferential clearing of some vegetation dictated by the land tenure and vegetation type. ▪ Timber industry begins in the Pilliga with the establishment of the first permanent mill.
1890s	▪ Major wildfire events.[3] ▪ Dense white cypress pine regeneration and, to a lesser extent, other species, leading to transformation to dense 'scrub' and abandonment of marginal grazing enterprises. This regeneration became known as the 1890s cohort. ▪ Government employment relief scheme to mitigate impacts of 1890's depression including white cypress pine thinning programs 1895.
1900s	▪ Rabbits enter the western side of the Pilliga Management Area and substantially reduce the extent of white cypress pine regeneration. ▪ Severe drought from 1900-1904. ▪ Ironbark sleeper cutting industry commences in the Pilliga Management Area in the early 1900s and by 1908 employs over 300 men.
1910s-1920s	▪ *Forestry Act 1916* proclaimed, requiring state forests to be managed in an ecologically sustainable manner. Prior to the 1920s logging generally removed

[3] Exact dates of wildfire events in the 1890s are unknown due to lack of historical data (Whipp et al. 2009).

Date	Event
	all merchantable timber in a stand. ▪ Rabbit population rises to plague proportions, with significant damage to vegetation during drought in the early 1920s.
1930s	▪ Forest stands from 1890s begin to stagnate due to their density and competition for water and nutrients. ▪ Thinning of white cypress pine regeneration and culling of competing hardwoods begins in better quality white cypress pine stands. ▪ In response to the Great Depression, specially funded manual labour becomes available, leading to manual thinning of white cypress pine by axe, construction of roads, fencing and fire-fighting infrastructure.
1930 – 1950	▪ Ringbarking of non-commercial hardwood trees and thinning of pine regeneration occurs with all potentially merchantable pine stems over 15 cm dbhob (diameter at breast height over bark) retained. ▪ 20 metre wide untreated 'green' fire break retained along all boundaries and internal roads. ▪ Unrestricted logging during World War 2 leads to over-cutting and imbalance in size classes 1939–1945. ▪ Specially formed committee proposes a plan for sustained yields in 1945, with each of the 14 mills operating in the Pilliga being allocated 3,010 cubic metres per year of white cypress pine sawlogs.
1950s	▪ Livestock grazing withdrawn from State Forests in 1950. ▪ Myxomatosis, a viral disease, was introduced to control the rabbit plague. Rabbit control and good rainfall encourages prolific regeneration of white cypress pine (1950s cohort) ▪ Log size class/royalty differential introduced to encourage processing of logs less than 18 cm cdob (centre diameter over bark). Mechanisation enables more efficient use of the ironbark resource, including larger trees. ▪ Major wildfire in the eastern and central part of the Pilliga in 1951, 1957 and 1958. ▪ 1080 rabbit poisoning program commences in 1959.
1960s	▪ Extensive culling of eucalypts in white cypress pine forests. Ringbarking replaced by frilling and poisoning in 1964. Thinning to favour vigorous white cypress pine growth. ▪ Sleeper production peaks in the mid-1960s. ▪ First management plan for the Pilliga forests approved by the Forestry Commission in 1968, establishing the Pilliga Nature Reserve. ▪ Livestock grazing allowed under grazing permits. ▪ Major wildfire in the eastern and central part of the Pilliga in 1966.
1970s	▪ Severe hail damage in Pilliga West. ▪ Nandewar forests combined with the Pilliga forests to become the Pilliga Management Area. ▪ White cypress pine spacing refined to 6 x 6 metres with a minimum of two

Date	Event
	trees (ironbark and other eucalypts) per hectare retained for wildlife habitat. ▪ Major wildfire in the eastern and central part of the Pilliga in 1974. ▪ Increased utilisation of ironbark for sawlogs and sleepers since 1979.
1980s	▪ Thinning of dense white cypress pine regeneration with brush cutters in State Forests. ▪ Cessation of hardwood poisoning in State Forests. ▪ Cessation of ringbarking of Eucalypts in 1982-1983. ▪ Return to livestock grazing under occupation permits. ▪ Major wildfire in the eastern and central part of the Pilliga in 1982. ▪ Severe hail damage in Yarrigan State Forest from 1983-84. ▪ Tussock grassland and sown pasture become the dominant vegetation types replacing almost all the open woodland, which remain mostly in isolated patches.
1990 - 2013s	▪ Major wildfire (140,000 hectares) in the eastern and central part of the Pilliga in 1997. ▪ White cypress pine can either be cleared, thinned or managed for forestry with approval under the *Native Vegetation Act 2003* (NSW) and associated regulations, including Invasive Native Scrub Property Vegetation Plans (PVPs) and Thinning (PVPs). ▪ Private Native Forestry (PNF), previously unregulated in NSW, came under the regulation of the *Native Vegetation Act 2003* through the PNF Code of Conduct, providing a third mechanism for managing white cypress pine on private land. ▪ Ironbark sleeper cutting ends. ▪ NSW Government's 2005 Brigalow decision led to changes in land tenure for white cypress pine state forests in the Brigalow Belt South and Nandewar bioregions, and impacted on Forests NSW's management of white cypress pine timber supply across NSW. ▪ In 2005 the Brigalow and Nandewar Community Conservation Area was established, creating a multiple-use reserve out of what were previously predominantly State Forests. These were zoned as Community Conservation Area Zone 1 – National Parks, Zone 2 – Aboriginal Areas, Zone 3 - State Conservation Areas and Zone 4 – State Forests. The Brigalow Assistance Fund, a funding assistance package for both the white cypress pine timber industry and reservation outcomes was provided. ▪ As a result of the Brigalow decision a new 20 year wood supply agreement between the NSW Government, Forests NSW and timber mills was reached. ▪ The State Conservation Areas are managed under the *National Parks and Wildlife Act* by the NSW National Parks and Wildlife Service. ▪ Winter and spring 2006 are the driest on record, with lightning igniting several fires. A series of wildfires burn over 300,000 hectares of forest. ▪ Major wildfire in Goonoo State Conservation Area 2007-2008. ▪ White cypress pine can be cleared or thinned without approval under the amended Native Vegetation Regulations 2013 (subject to proposed conditions).

Date	Event
	White cypress pine is listed as invasive native species in some areas of NSW. ▪ Major wildfire destroys 80% of the Warrumbungle National Park and areas surrounding the park, including homes.

Attachment 15 – Plant species composition analysis

The NRC obtained an extensive survey dataset of plant species abundance across multiple sites within white cypress pine habitats. Survey data was collected by Dr John Hunter between November 2008 and October 2013 (see for example J. T. Hunter, 2008a). Plant species were recorded in 20 x 20 metre sample plots across 106 sites in north central NSW. Seven of the sample sites were in State Conservation Areas.

The surveys were commissioned by the NSW Office of Environment and Heritage as baseline data to characterise the plant species of each selected State Conservation Areas and National Parks (J. T. Hunter, 2008a, 2008b). Initial interpretations of these data focused on species richness with the objective to assess correspondence between on-site environmental indices (altitude, aspect, soil condition) and species density (J. Hunter, 2011, 2013).

Plant species richness

Across all State Conservation Areas in the sample subset, 671 plant species were recorded from 233 sample plots. The NRC found 3 species occurred in over half the sample plots (*Austrostipa scabra, Cheilanthes sieberi, Aristida personata*) and 186 species (28 percent of the total) occurred in just one sample plot. Over half of recorded species (52 percent) occurred in 3 or fewer sample plots.

The NRC found there were 28.5 plant species on average recorded per 20 x 20 metre sample plot with no significant difference in the average number of species per sample plot between State Conservation Areas (ANOVA, F=1.16, P=0.33, **Table A15.1**). The average number of species per sample plot was between 7 and 24 percent of the total number of species recorded in the State Conservation Area, a pattern consistent with the majority of species being present in just a few sample plots.

Table A15.2 compares plant species richness found in this analysis with similar forest habitats elsewhere.

Table A15.1: Average similarity between samples within a State Conservation Area

State Conservation Area	Number of plots sampled	Plant species richness (total species observed)	Number of species recorded in <5% of plots (percent of total)	Likely total species richness (Chao2)	Average number of plant species per plot	Species per plot as a proportion of total richness (percent)
Biddon	23	213	90 (42)	314	28	13
Bobbiwaa	21	182	71 (39)	250	27	15
Pilliga West	8	131	-	175	32	24
Killarney	19	133	60 (45)	233	25	19
Pilliga East	26	218	92 (42)	321	28	13
Pilliga	77	391	261 (67)	571	28	7
Trinkey	35	277	146 (53)	390	32	12
Totals	209	654	532 (79)	-	-	-

Table A15.2: Plant species richness in survey plots from a range of pine forest habitats

Forest type	Plant species richness per sample plot	Plot size (hectare)	Plant species richness per standard 0.04 hectare plot[4]	Source
White cypress pine	29	0.040	29	this analysis
Ponderosa pine woodland	35	0.050	44	(Laughlin & Abella, 2007)
Douglas fir plantation	20 - 26	0.025	13 - 16	(Thomas, Halpern, Falk, Liguori, & Austin, 1999)
Old-growth *Pseudotsuga* forest	32-80	0.024	19 - 48	(Halpern & Spies, 2009)
Conifer forest	8 - 24	0.031	6 - 19	(Battles, Shlisky, Barrett, Heald, & Allen-Diaz, 2001)
Ponderosa pine forests	25	0.038	24	(Griffis, Crawford, Wagner, & Moir, 2001)

Extrapolations to predict the expected number of species (S) in each State Conservation Area using the permutation based S estimator Chao2 in PRIMER suggested that each State Conservation Area

[4] This proportional adjustment of recorded species richness to a standardised 0.04 hectare plot size is only an approximation as it does not take into account the shape of the species area curve that will differ between habitat types.

has between 175 and 571 species (**Table A15.1, Figure A15.2**). These predicted totals were, on average, 47 percent higher than the observed number of species in the survey samples.

These analyses support the conclusion that plant survey plots in the State Conservation Areas were species rich with the majority of species uncommon in the sample set.

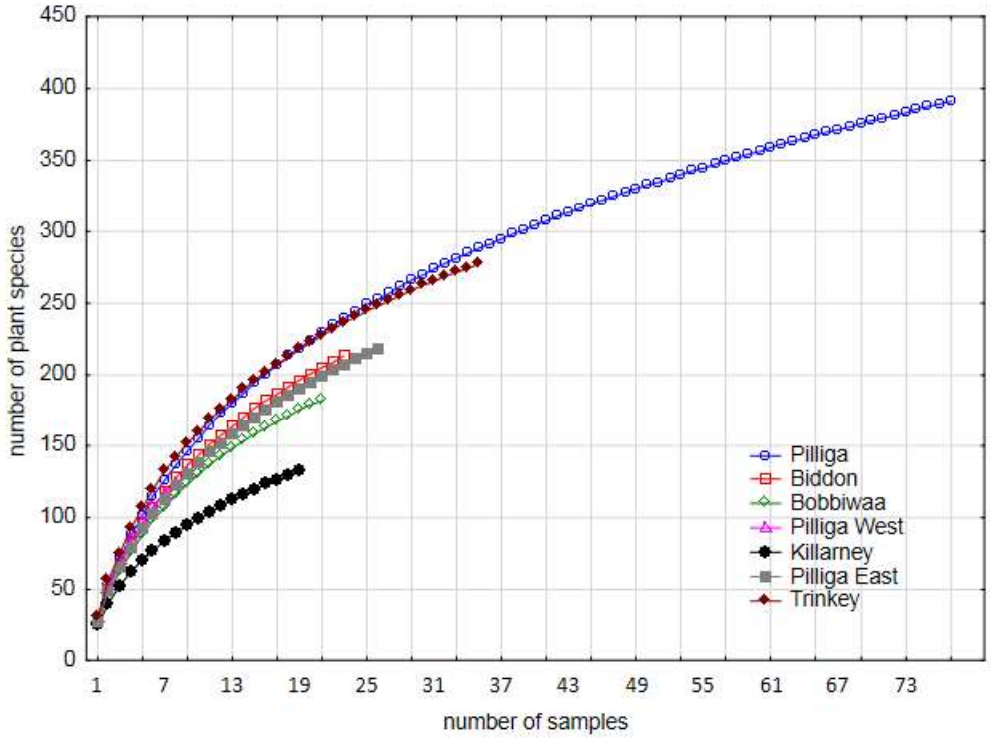


Figure A15.2: Plant species accumulation curves based on 20 x 20 metre survey samples for selected State Conservation Areas. Curves are averaged from multiple permutations of sample sequences

Similarity

Plant species composition varied between sample plots within a State Conservation Area. Average plant species similarity between sample plots within a State Conservation Area was 24.9 (potential range of 0 to 100) meaning that, in most cases, pairs of samples from *within* a State Conservation Area had just a quarter of plant species in common (**Table A15.3**).

Low similarity between sample plots within a State Conservation Area also persisted when uncommon taxa were removed from the analysis. When the uncommon species were removed (species that occurred in less than 5 percent of samples) average similarity only increased by 7 percent.

The top five plant species contributing to similarity within a State Conservation Area (species that tend to characterise an entire site as opposed to a single sample plot) only accounted for 34.5 percent of similarity on average (**Table A15.3**). This suggests that beyond the obvious characterisation of the dominance of white cypress pine (a criterion for plot selection) there were no obvious co-dominant species occurring consistently enough among plots to characterise a State Conservation Area.

Table A15.3: Average similarity between samples within a State Conservation Areas

Community Conservation Area	Average similarity (presence/absence)	Average similarity (uncommon species removed)	Percentage contribution (top 5 species)
Biddon	21.4	27.7	29.2
Bobbiwaa	24.2	31.2	38.2
Pilliga West	31.5	42.8	35.7
Killarney	35.4	41.3	39.3
Pilliga East	25.4	32.7	33.4
Pilliga	18.8	23.6	25.2
Trinkey	23.6	30.0	36.4

Although plant species composition differed between sample plots *within* a State Conservation Area, there was also a statistically significant difference in plant species composition *between* State Conservation Areas. Measured as *dissimilarity* in plant species composition (the reciprocal of similarity), this difference in biodiversity between State Conservation Areas averaged 86.6 meaning that, on average, State Conservation Area differed in plant species composition. All pairwise comparisons of dissimilarity between State Conservation Areas were greater than 75.0 (Bobiwaa, Killarney; with the largest difference between Pilliga West and Pilliga East, **Table A15.4**), and were statistically significant overall in all pairwise comparisons (ANOSIM, Global R=0.347, P=0.001) (**Table A15.4**).

Table A15.4: Overall dissimilarity in pairwise comparisons of State Conservation Areas

	Biddon	Bobbiwaa	Pilliga West	Killarney	Pilliga	Pilliga East	Pilliga
Biddon	0	-	-	-	-	-	-
Bobbiwaa	86.08	0	-	-	-	-	-
Pilliga West	90.54	87.83	0	-	-	-	-
Killarney	83.88	75.03	85.66	0	-	-	-
Pilliga	89.76	90.15	84.16	89.52	0	-	-
Pilliga East	85.25	90.29	92.59	89.89	88.44	0	-
Pilliga	86.50	89.73	86.56	86.75	84.54	84.26	0
Trinkey	85.05	86.22	84.06	84.10	86.54	84.53	85.45

To visualise this biodiversity difference between State Conservation Areas, Bray-Curtis similarity values were plotted on a multi-dimensional scaling (MDS) plot (**Figure A15.3**). Points closer together on the graph represent samples that are more similar in species composition that those further apart. Samples from the same State Conservation Area are clustered together in this representation of multi-dimensional space. Although there was considerable difference between samples within a State Conservation Area, these samples tended to cluster in the two-dimensional representation of multi-dimensional space more than would be expected by chance (**Figure A15.3**).

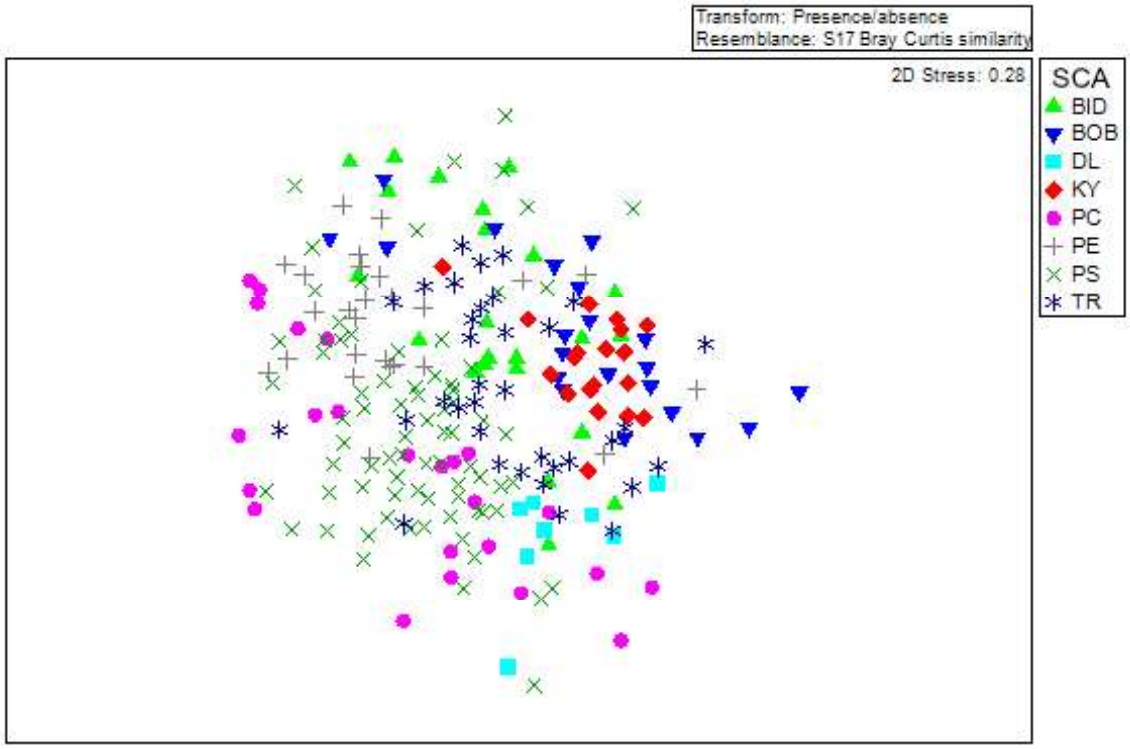


Figure A15.3: Multi-dimensional scaling (MDS) plot of plant species composition per sample (distance between points reflects relative difference in species composition) in Bidden (BID), Bobiwaa (BOB), Killarney (KY), Pilliga West (DL), Pilliga East (PE), Pilliga (PS), and Trinkey (TR) State Conservation Areas

Differences in plant species composition *between* State Conservation Areas were large and significant. The most likely reason for this outcome is the high overall plant species richness and changes in the plant species that make up that richness from sample-to-sample.

Each State Conservation Area contributed to the overall pool of sampled species. On average each sample plot added 1.4 unique species and each State Conservation Area contributed between 2.3 to 14.7 percent of unique species to the 654 observed plant species in the sample set (**Table A15.5**).

Table A15.5: Contribution of each State Conservation Area to the total number of species recorded in the sample set

State Conservation Area	Number of plots sampled	Plant species richness (total species observed)	Number of species recorded only in the SCA	SCA contribution to observed plant species richness (%)
Biddon	23	213	30	4.6%
Bobbiwaa	21	182	26	4.0%
Pilliga West	8	131	21	3.2%
Killarney	19	133	15	2.3%
Pilliga East	26	218	33	5.0%
Pilliga	77	391	96	14.7%
Trinkey	35	277	42	6.4%
Totals	209	654	263	40.2%

Overall, plant species similarity analyses within and between State Conservation Areas suggested that:

- on average, pairs of samples within a State Conservation Area had a quarter of species in common
- State Conservation Areas differ in plant species composition
- each State Conservation Area contributed between 15 and 96 plant species to the total number of plant species in the sample set.

Attachment 16 – Commercial opportunities

As part of its Terms of Reference, the NRC has investigated commercial opportunities of ecological thinning that are currently available as well as those with future potential. In undertaking this analysis the NRC sought advice from URS Australia Pty Ltd and Enecon Pty Ltd.

1.1 Commercial opportunities linked to sawlogs

The Brigalow and Nandewar sawmilling industry currently produces a range of solid wood products that are sold primarily into NSW and Victorian domestic markets. White cypress pine is often used in the landscaping market and has an advantage over treated timbers due to its natural durability and termite resistance (Cypress Industry Strategic Plan Group, 2003). In terms of current market conditions and their impact on price and volume, the most successful products appear to be posts and pickets (Gunnedah Timbers Pty Ltd, Baradine Sawmilling Company, pers. comm., 2013).

Active and adaptive management in State Conservation Areas, through ecological thinning, could generate a supply of production logs that are suitable for processing as timber products, similar to the sawlog supply from State Forests. However, in practice the supply from an ecological thinning program in State Conservation Areas could vary significantly within and between years, in contrast to the more stable production volumes supplied from State Forests. As a result, the sawmills are likely to access the supply of production volumes from State Conservation Areas on a short-term (one to three years of potential supply) or opportunistic basis.

The supply of production volumes to the sawmills has the potential to increase mill throughput. Given the surplus capacity currently available at both the Baradine and Gunnedah mills, additional volume would improve the sawmills' return on capital by allowing one or both of the mills to move to a double shift operation, which would lower unit production costs and increase the mills' income. However, the strength of timber markets will influence whether sawmills agree to take additional volume; sawmills are most likely to be interested when confident of selling this additional product.

White cypress pine timber markets are influenced by domestic housing markets, which have been weak over the past decade (Australian Bureau of Statistics, 2013; Reserve Bank of Australia, 2013). Domestic timber producers have also been impacted by increased competition from imports. However, the marked increase of new building activity in NSW in the past 12 to 18 months may increase demand for white cypress pine products and therefore improve returns to the local timber industry. Expected growth in the property alterations and addition market could also increase demand for white cypress pine flooring, landscaping and decking products.

Additional production volume also has the potential to improve the quality of the overall log mix provided to the sawmills, compared to the State Forest supply under existing agreements with Forestry Corporation of NSW.

Sawmills benefit from increases in average log size, particularly as larger logs allow more efficient production and greater flexibility to meet changing market demands (see **Table A16.1)**. For example, although there is little cost difference in the production of posts, the value premium of a 150 millimetre square post over a 100 millimetre square post is estimated to be around 25 to 30 percent, and for a 200 millimetre over a 100 millimetre post it is around 40 percent. Conversely, as log size decreases, unit rates of handling costs increase, green recovery in the log breakdown decreases and the range of products that can be cut from the log is reduced.

Table A16.1 Estimated wholesaler buying and selling prices for a range of cypress products[5]

Product	Size	Delivered buying price (free in store) ($ per cubic metre)	Retailing selling price ($ per cubic metre)
Fence posts	100 by 100 millimetres	$650-750	$900-1,000
	125 by 125 millimetres	$650-750	$900-1,000
	150 by 150 millimetres	$950-1050	$1,200-1,300
	200 by 200 millimetres	$1,050-1,150	$1,300-1,400
Pickets	150 by 12 millimetres	$800-900	$1,000-1,100
Structural timber	100 by 50 millimetres	$700-800	$850-950
Flooring	100 by 25 millimetres	$1,100-1,200	$1,600-1,800
Decking	100 by 25 millimetres	$1,000-1,300	$1,500-1700
Weatherboards	150 by 25 millimetres	$1,000-1,300	$1,700

1.2 Commercial opportunities linked to smaller logs

Currently, there are no significant markets within the sawmilling industry for material similar to the non-production volumes presented in **Box 5 in Section 11.2.2**)

A viable forest products industry needs to have markets available for small logs and wood residues in order to use all of the forest resource and supplement income produced from sawlog processing. The Brigalow and Nandewar sawmills currently produce around 14,500 cubic metres of residues annually and supply a range of small volume customers. Small sawlogs processed by the mills are turned into pickets (which can deliver a return to the sawmilling business), or other small dimension boards.

There may be opportunities for the sawmills to explore markets for lower quality logs and smaller dimension timber. In particular, lamination processes allow a larger dimension product to be engineered using timber from small logs and thinnings material. This could add value to the relatively large volume of small boards currently produced by the Gunnedah mill. This product is already being produced in the Australian market, through the lamination of two lower value 100 x 50 millimetre cypress boards to produce a higher value 100 x 100 millimetre cypress post.

However, while trials based around these technologies have been explored, at present no existing commercial enterprise is using a significant volume for smaller sized logs. In general, producing a laminated product using a larger number of smaller dimension boards would be a higher-cost operation compared with current production processes, as the sawmills are likely to incur higher delivery costs, and significant upfront capital costs to efficiently process smaller-sized logs. Cost efficiencies could be obtained if an ecological thinning program generating non-production volumes were integrated with a similar Forestry Corporation of NSW program in State Forests.

In the softwood industry, small log processors use lower quality wood for producing paper products, engineered panels and woodchips for export. The Brigalow and Nandewar white cypress pine industry is constrained in supplying these markets, firstly by distance to the nearest

5 Prepared with the assistance of URS Australia.

processor and secondly by the limited and variable volume of white cypress pine residues generated to justify regional investment in these operations.

The market for mulch, composts and other low-value products is likely to have grown over time as home owners spend more on their gardens and seek lower maintenance solutions for limiting moisture loss and reducing weed growth in garden beds. The local landscaping firm in Gunnedah operates in a slightly differentiated market segment as its products are marketed as cypress products with superior qualities to standard grade, non-species-specific products. Landscaping mulch and composts processed by the landscaping sector are likely to be predominantly purchased and traded by garden centres, Do-It-Yourself stores and professional landscapers.

While an additional supply of non-production volume has the potential to increase throughput for the local landscaping firm, its ability to pay costs incurred in extracting and delivering non-production-grade logs from State Conservation Areas is not tested.

Efficiency and market opportunities

While export markets have declined, maintaining a presence in these markets would allow the sawmills to capture improved international market conditions for sawlogs in the future.

Increased prices for larger logs due to increased domestic or export demand, or the development of new markets (such as architectural cladding), would increase the margin for these products and may allow the mills to supply markets with higher volumes. Modelling undertaken for this review indicates that an increase in sale price of landscaping posts by 10-15 percent could improve the mills' enterprise gross margin by 3-4 percent.

There may also be opportunities for sawmills to recover processing costs and reduce wastage of their raw product. For example, the addition of chippers at the mills has allowed the firms to improve resource recovery from sawlogs. Changing sawing configurations to process smaller logs at higher speed and more efficiently could also help to improve the mills' resource recovery.

1.3 Commercial opportunities within the bioenergy and biofuels sector[6]

Bioenergy and biofuels markets provide a range of potential end uses for non-sawlog material. These markets can use biomass from ecological thinning and fibre generated by the wood processing supply chain.

The NRC's review indicates that market opportunities for non-production ecological thinning residues in the short term, including for bioenergy and charcoal, are limited. Given the variable nature of the resource, large scale commercial use of ecological thinning residues from State Conservation Areas may only be possible if they are considered as part of a broader woody biomass resource in the region. In particular, biomass from ecological thinning in State Conservation Areas could be used to augment biomass supplies from any thinning programs undertaken by Forestry Corporation of NSW.

Opportunities linked to electricity generation

The NRC has identified electricity generation as the most promising potential commercial opportunity for the use of ecological thinning residues in the Brigalow and Nandewar region. However, use of biomass from State Conservation Areas for this application is currently prohibited

6 Report prepared for the NRC by Enecon Pty Ltd, June 2014.

under NSW regulation. Further, under national legislation, biomass from State Conservation Areas is not eligible for renewable energy certificates under the Renewable Energy Target, and the Target itself is currently under review (for further discussion of legislative barriers see **Section 13.2**).

Assuming a combined source of biomass from State Conservation Areas and State Forests, the NRC has costed a five megawatt plant located next to a customer; in this case, assumed to be a sawmill similar to those currently located at Gunnedah or Baradine. Key determinants for the cost of electricity from a biomass plant are the economy of scale of the plant, biomass fuel costs and the running time of the plant.

It is expected the mill could purchase electricity from the power plant to replace retail electricity that would otherwise be purchased through the grid, at an assumed price of $200 per megawatt hour. This gives the power plant a significant price premium over electricity sold into the grid (the sale price to grid is assumed to be $100 per megawatt hour, which includes the value of a renewable energy certificate). The more electricity purchased by the sawmill, the greater the total revenue for the power plant.

The amount of electricity purchased by the mill will depend on the mill's operating regime and machinery. This regime will change in response to variations in saw log availability and quality, and markets for finished products (quantity and type, for example green wood or kiln-dried products). As such, several scenarios for sawmill operation were modelled. In each case the average price paid for the five megawatts of power is calculated, followed by the price that can be paid for the wood feed to generate that power.

Results of the economic analysis for a five megawatt plant are provided in **Table A16.2** Provision of wood feed at these differing price points will vary based on a number of factors. Prices are significantly less than the full cost incurred in harvesting, chipping and delivering the wood to a bioenergy plant. The prices listed would therefore only occur on a marginal cost basis, such as harvest or delivery costs being incurred by a wood processor. Additional assumptions and specifications within the costing model are listed in **Table A16.3.**

Table A16.2: Economic analysis of a five megawatt bioenergy plant

Electricity consumption by saw mill operation	Average price paid to power plant for electricity ($ per megawatt hour)	Price payable for wood feed ($ per tonne)
Nil – electricity sales to grid only	100	23
5 shifts per week and 1 megawatt average power use	105	27
5 shifts per week and 2 megawatt average power use	110	31
10 shifts per week and 2 megawatt average power use	119	38

Table A16.3: Assumptions used for the economic analysis of a five megawatt bioenergy plant

Item	Value
Gross electrical output	5.5 megawatts (electric)
Technology	High-temperature hot oil heater, organic Rankine cycle unit
Feed requirements	51.2 kilotonnes per year (dry feed[7])
Capital cost	$18 million
Operation & maintenance cost	$1.2 million per year
Unit capital cost	$3.6 million per megawatt (electric)
Project life	20 years from initial investment
Residual value of plant	Assumed to be nil
Construction period for the plant	18 months
Commissioning period	Included in construction period
Production ramp up	Immediate full production and full product purchase
Inflation of costs and revenue each year	2.75 percent for costs, 2.75 percent for revenue
Depreciation	Straight line over 15 years
Company tax rate	30 percent
Interest on any borrowings	8 percent, with principal repaid at end of project
Financing	50 percent equity financing
Plant operation	8,000 hours per year (leaving time for scheduled shutdowns and maintenance)
Sawmill operation	12 x 28-day billing periods, plus one month maintenance
Required project internal rate of revenue	10 percent after tax
Working capital	Not included

Longer-term opportunities within the bioenergy and biofuels sector

There are some potential markets that are undeveloped or developing within Australia that may provide commercial opportunities in the future.

In some potential growth markets demand for biomass is likely to be met with lower value residues. For example, growth in the wood pellet market is likely to rely on lower value sawmill waste streams, and the initiation of a market for biochar is likely to be based on nil value or negative value material such as urban green waste. Similarly, while ecological thinning residues can be used for power station co-firing or heating fuel (via fast pyrolysis oil), high grade metallurgical charcoal and activated carbon, barriers including high entry costs and alternative biomass sources which are less expensive would need to be overcome.

Advanced biofuels (ethanol and hydrocarbons made from wood that can be used interchangeably with existing fuel sources with no need for blending) may provide a commercial use for ecological thinning by-products in the future, although other sources of biomass would also be required to achieve the scale of fuel production occurring in plants. Internationally, advanced biofuels are the

7 Based on ecological thinning residues being left to dry in the forest after initial harvest and then brought into the power station at 15 percent moisture content (15 gigajoules per tonne heating value). If wood was not left to dry, green wood immediately after harvest would be assumed to have 40 percent moisture content (10 gigajoules per tonne heating value) requiring a feed of around 77.6 kilotonnes per year.

subject of billions of dollars of commercial investment, which is expected to lead to the availability of multiple commercially demonstrated technologies over the next few years.

1.4 Commercial opportunities for firewood

There is limited potential for white cypress pine residues to be used as a firewood species. White cypress pine is generally considered a low quality firewood due to high levels of extractive content in the wood. It produces relatively low amounts of heat and low quality coals and it 'sparks' when burned. The high resin content also clogs chimneys when used indoors, creating a fire hazard. Its main potential in the firewood market is as kindling because of its ease of ignition, fast burn rate and clean splitting.

An existing commercial firewood business in Gwabegar supplies eucalypt firewood sourced from State Forests to the Blue Mountains and Sydney markets. This firewood consists of local ironbark species harvested as part of an integrated white cypress pine management regime.[8]

Bulloak, another potential firewood species in white cypress pine forests, remains largely unused as firewood. Bulloak is not a commercial timber species due to its small size and low grade recovery. However, it is extremely hard and is reported to have good properties as a firewood species. Bulloak does not have the sparking issues associated with white cypress pine and produces coals. Although it is not often used or well known as a domestic firewood species, it has good potential in this market due to its consistent heat when burned. However, it does create more ash when compared to hardwood species.

The development of a bulloak firewood market could potentially improve cost efficiencies of harvesting white cypress pine. Hardwoods are currently the preferred firewood species, and targeted marketing and promotion would be required to make bulloak a viable alternative to ironbark.

8 *Eucalyptus paniculata, Eucalyptus siderophloia, Eucalyptus sideroxylon* and *Eucalyptus crebra.*