NSW GOVERNMENT Natural Resources Commission

FINAL REPORT

Brigalow and Nandewar State Conservation Areas

Actively managing for better ecological outcomes

September 2014

Enquiries

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List of acronyms

ADS40	Digital Image Acquisition System
Cth	Commonwealth (Australian Government)
LiDAR	Light Detection and Ranging
MCAS-S	Multi-Criteria Analysis Shell for Spatial Decision Support
NRC	Natural Resources Commission
NSW	New South Wales
SCaRPA	Site and Catchment Resource Planning and Assessment
SLATS	Statewide Landcover and Trees Study

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Table of Contents

Part I – Summary

Part II - Managing differently to achieve better outcomes

Part IV - Attachments

Part I – Summary

Executive summary

The NSW Premier asked the Natural Resources Commission (NRC) to investigate active and adaptive management of cypress forests in the State Conservation Areas of the Brigalow and Nandewar Community Conservation Area (refer to **Figure 1** and **Figure 2** for maps).

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, while 2.5 percent (or 195,095 hectares) is state conservation area.

The national parks, state conservation areas, and state forests within the Brigalow and Nandewar region are ecologically and culturally significant. The Brigalow and Nandewar State Conservation Areas provide habitat for threatened species and support Aboriginal values, recreation, research and education, apiary and mineral and petroleum exploration and extraction.

The NSW Government intended that the Brigalow and Nandewar Community Conservation Area would provide an innovative new land management tenure, supporting coordinated cross-tenure land management with strong community involvement. However, current management within the Brigalow and Nandewar State Conservation Areas may not be delivering optimal ecological outcomes. In particular, there is a risk that large stands of dense vegetation, specifically white and black cypress pine and bulloak, are adversely impacting ecological values.

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 cypress pine woodlands have been transformed into denser forest or scrub formations.

While small patches of dense vegetation provide habitat for native flora and fauna within a landscape mosaic, large areas of dense vegetation are likely to have negative impacts on a range of ecological values, including biodiversity. For example, they reduce the diversity of native vegetation types and structures in the landscape, which can have negative impacts on habitats and soil health.

In areas with large stands of increasingly dense vegetation, active interventions including ecological thinning, prescribed burning and targeted grazing can improve vegetation structure and composition. The benefits of these interventions include increased landscape heterogeneity, groundcover, and regeneration and growth of trees that improve ecological habitat. Ecologically, cypress forests within the Brigalow and Nandewar State Conservation Areas are very different from forests in coastal regions. Management interventions that are likely to benefit these unique forests are not necessarily appropriate for other forest types.

The NRC undertook spatial analysis to understand the extent, distribution and density of cypress and bulloak within the Brigalow and Nandewar State Conservation Areas. This analysis identified stands of cypress and bulloak of varying density, with around 15 percent of the total area assessed as having higher densities of cypress or bulloak. Pilliga, Pilliga West, and Trinkey State Conservation Areas were identified as having the largest areas of denser vegetation.

The State Conservation Areas are dynamic landscapes. The extent of dense cypress and bulloak stands could expand or contract in the future due to natural disturbances and/or management activities. However, recent studies suggest that the extent and density of cypress and bulloak has expanded, and is likely to increase further under future climate change predictions.

The existing plans of management do not address the impact of increasing vegetation density on forest structural diversity and habitat values. To change the likely trajectory of the cypress forests and ensure they support a greater variety of ecological outcomes through increased structural and floristic diversity, the NSW Government will need to adopt a new way of managing these areas.

The NRC recommends that the NSW Government:

- **actively manage large stands of increasingly dense vegetation where it has potential to impact ecological values –** a range of management options, including ecological thinning, should be available to land managers to address large stands of dense vegetation that are impacting ecological values. These interventions can increase landscape heterogeneity, promote groundcover and improve ecological habitat
- **adaptively manage the Brigalow and Nandewar State Conservation Areas** - adopt contemporary best practice active and adaptive landscape management to give land managers the flexibility to test, evaluate and improve management strategies and actions
- **develop, implement and resource new plans for the Brigalow and Nandewar State Conservation Areas –** create an Adaptive Management Plan that will guide the development of new or revised plans of management for the State Conservation Areas, particularly for the priority areas of Pilliga, Pilliga West and Trinkey State Conservation Areas
- **identify and apply alternative funding, cost sharing and cost recovery models –** where appropriate, seek secondary commercial benefits to off-set costs and improve long-term sustainability of programs being undertaken to enhance environmental outcomes.

The NRC's report discusses each of these recommendations in detail, and gives information about updated governance and accountability arrangements and revisions to legislation to support active and adaptive management.

The report also explores the potential cost of actively managing dense vegetation, and the likely social and economic outcomes these activities, including the potential for minor benefits to the local timber industry.

As an example, the NRC modelled an ecological thinning program treating denser areas of vegetation in Pilliga, Pilliga West and Trinkey State Conservation Areas over five years. Overall, the NRC estimates that the modelled ecological thinning program would cost in the vicinity of $3.85 million to $7.1 million over five years, depending on thinning intensity. By putting cost recovery mechanisms in place, the NRC estimates that costs for the modelled program could be reduced by up to 65 percent under a cost recovery scheme, incurring a total program cost of between $2 million and $2.5 million. Under a goods for services scheme, cost reductions will vary, with Government incurring only program management costs of around $0.95 million for the five year program as a best case scenario.

It is important to make a distinction between ecological thinning and commercial harvesting (or logging). The purpose of an ecological thinning program is to selectively remove trees or dense stands of vegetation to achieve specified ecological outcomes. Unlike commercial harvesting practices, the primary focus of ecological thinning programs is not the promotion or extraction of merchantable timber, though products with commercial value may be a secondary by-product.

The NRC has obtained legal advice that residues generated from ecological thinning could be used for secondary commercial purposes as part of cost recovery initiatives, providing the interventions have been carried out for the primary purpose of delivering positive environmental outcomes.

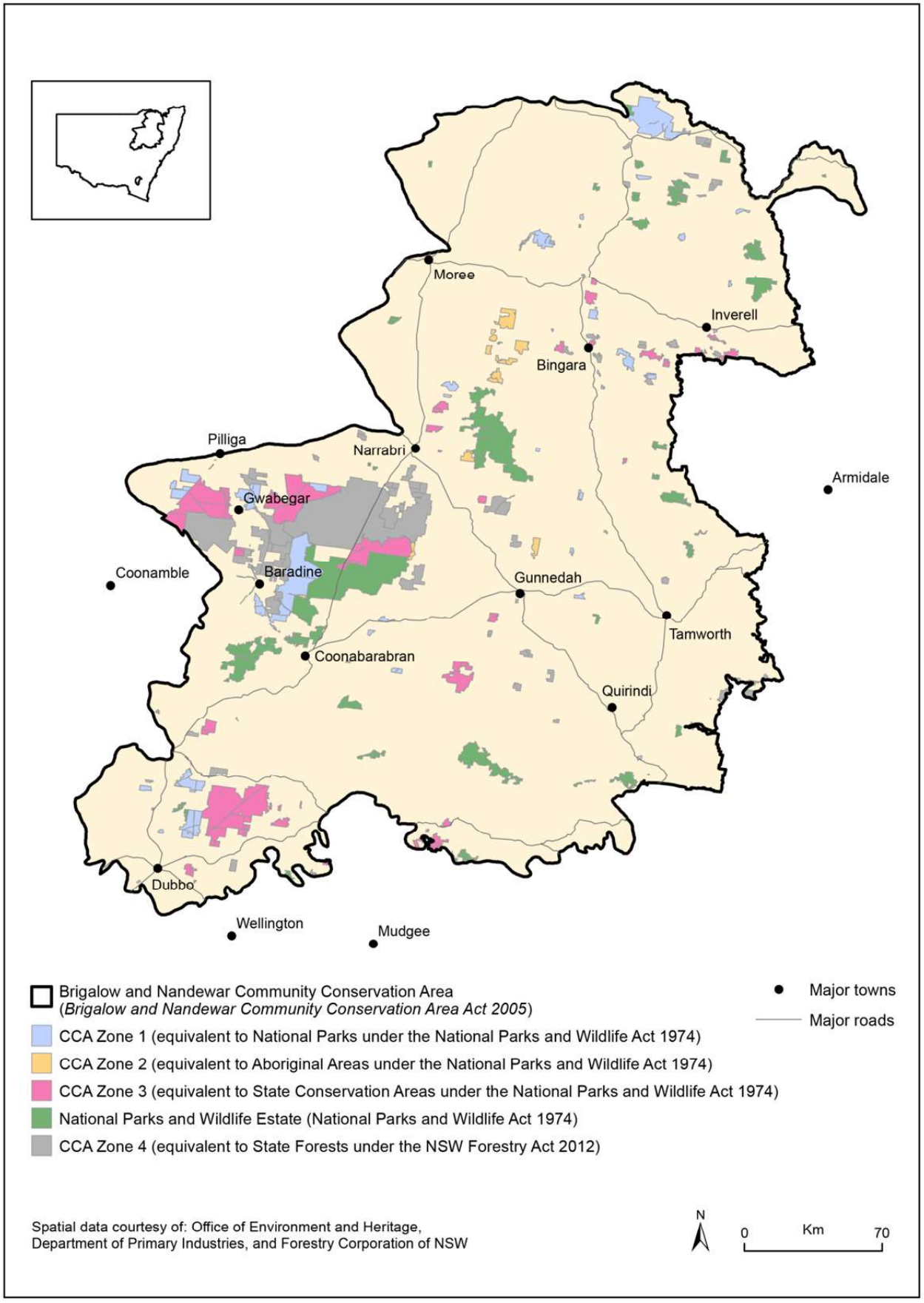


Figure 1: Map of the Brigalow and Nandewar Community Conservation Area (the State Conservation Areas are Zone 3 within the Brigalow and Nandewar Community Conservation Area)

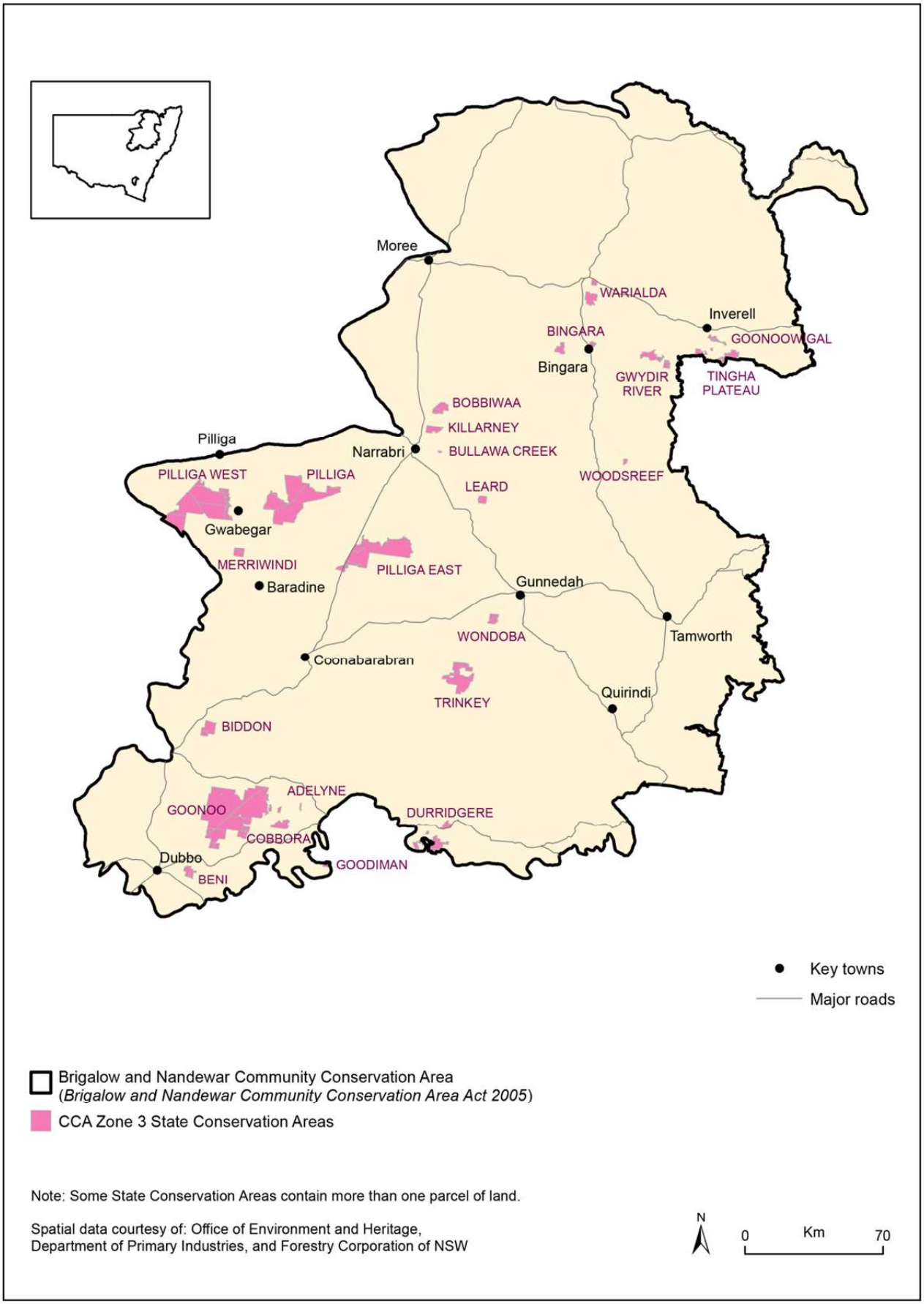


Figure 2: Map of the Brigalow and Nandewar State Conservation Areas

1 Recommendations

1 Actively manage dense vegetation to improve environmental outcomes

The NRC recommends that:

1(a) conservation managers are given the flexibility to apply a variety of active management tools – including ecological thinning, prescribed fire and targeted grazing (as appropriate) – within an adaptive management framework for the purpose of actively managing large stands of increasingly dense vegetation to maintain or improve environmental outcomes

1(b) any ecological thinning be guided by the principles set out in **Table 23 (page 94)**

1(c) the NSW Government review the findings and recommendations from the current grazing trial in south-western cypress reserves to inform the potential application of targeted grazing in the Brigalow and Nandewar State Conservation Areas.

2 Adaptively manage the Brigalow and Nandewar State Conservation Areas to deliver better environmental outcomes

The NRC recommends that:

2(a) the NSW Government develop and implement an Adaptive Management Plan for the Brigalow and Nandewar State Conservation Areas that:

- sets out at a high level the principles and processes for adopting an active and adaptive management approach
- facilitates adaptive governance and cross-tenure collaboration.

3 Develop, implement and resource new plans of management for the Brigalow and Nandewar State Conservation Areas

The NRC recommends that:

3(a) consistent with the overarching Adaptive Management Plan, new or revised plans of management for the Brigalow and Nandewar State Conservation Areas are developed that include specific, measurable and spatially explicit management targets

3(b) to streamline plan development and implementation, the 23 Brigalow and Nandewar State Conservation Areas should be divided into a smaller number of functional management groups, informed by consultation with relevant National Parks and Wildlife Regional Advisory Committees

3(c) in developing new and revised plans of management, the Office of Environment and Heritage draw on the spatial analysis undertaken by the NRC in this review to further investigate the management requirements of areas of dense vegetation within the Brigalow and Nandewar State Conservation Areas

3(d) the Office of Environment and Heritage prioritise the development of plans of management for Pilliga, Pilliga West and Trinkey State Conservation Areas to address the management of large stands of increasingly dense vegetation in these areas

3(e) monitoring, evaluation and reporting for these plans 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.

4 Identify and apply alternative funding, cost sharing and cost recovery models

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) where practical, the NSW Government use a 'goods for services' scheme as the preferred means of cost sharing when implementing an active and adaptive management program.

5 Update governance and accountability arrangements

The NRC recommends that:

5(a) current governance arrangements are 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 representatives with adaptive management expertise

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

5(c) an outcomes based performance audit model is used to provide accountability for active management programs, including ecological thinning programs

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

6 Ensure legislation supports active and adaptive management

The NRC recommends that:

6(a) the over-arching Adaptive Management Plan for the Brigalow Nandewar State Conservation Areas become a legislative requirement, to be completed and implemented by the Office of Environment and Heritage within a specified time and approved by the Minister for the Environment

6(b) approval of plans of management for the Brigalow and Nandewar State Conservation Areas be devolved to relevant National Parks and Wildlife Service regional managers

6(c) the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) and existing Brigalow and Nandewar State Conservation Area plans of management be amended to expressly provide for the secondary commercial use of residues derived from ecological thinning undertaken with the primary objective of improving ecological outcomes

6(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

6(e) the NSW Government support the Renewable Energy Target Expert Panel's recommendation to the Australian Government on amendments to the *Renewable Energy (Electricity) Regulations 2001* (Cth) to recognise the use of ecological thinning residues under the Renewable Energy Target.

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.

The Brigalow and Nandewar State Conservation Areas (referred to in this report as 'the State Conservation Areas', and also known as the Community Conservation Area Zone 3) account for around 2.5 percent of the Brigalow and Nandewar Community Conservation Area.
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.

In this review, the term 'cypress forests' refers to all vegetation communities[1] dominated by or associated with white cypress pine (*Callitris glaucophylla*[2]) and black cypress pine (*Callitris endicheri*), including woodland vegetation communities.

These cypress forests have different ecosystem functions and ecological issues compared with forests in coastal regions. The management interventions that are likely to benefit these unique forests are not necessarily appropriate for other forest types.

This chapter summarises the key findings of the NRC's review. Full details of the review, including references and evidence to support these findings, are found in the remainder of the report.

2.1 Managing dense vegetation in the State Conservation Areas

2.1.1 Past management and changes in the landscape

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.

The exact structure and composition of the pre-European landscape is subject to debate. However, there is general agreement that since European settlement, many formerly open grassy cypress pine woodlands have transitioned to denser forest or scrub formations dominated by white and black cypress pine, and in some areas bulloak[3] (*Allocasuarina luehmannii*).

1 A collection of plant species occupying a particular area.
2 Sometimes referred to as the eastern coastal cypress (*Callitris columellaris)*.
3 Also referred to as buloke, bull oak, or bull sheoak.

There is a strong consensus in the scientific literature that diverse vegetation mosaics and their associated habitats are critical in supporting regionally diverse native flora and fauna, and ecological processes at different scales.

Small patches of dense cypress or bulloak provide important habitat for native flora and fauna within a landscape mosaic and, as such, some stands of dense vegetation should be retained in the landscape.

However, large areas of dense vegetation that are uniform in height can decrease biodiversity values and have an impact on canopy trees. In particular, the shift from eucalypt to cypress pine-dominated vegetation communities is likely to have had significant effects on the fauna that rely on eucalypts for shelter, nesting hollows and food provision. For example, a decrease in eucalypts is likely to have caused a major decline in nectar provision in some areas of NSW. Studies in the Pilliga and Goonoo forests also found low densities of hollow-dependent species, suggesting that these ecosystems are under stress.

Some large stands of dense cypress pine and bulloak should therefore be actively managed to provide a more structurally and floristically diverse habitat mosaic within the State Conservation Areas.

2.1.2 Potential future trajectories and the need for management

The State Conservation Areas are ecologically dynamic. The extent of dense cypress and bulloak could expand or contract under the influence of different natural disturbances and management activities.

However, recent studies by Cohn et al. (2012) and Whipp et al. (2012) suggest that:

- the extent and density of cypress pine and bulloak has expanded
- under future climate change predictions, the extent and density of cypress pine and bulloak is likely to continue to expand.

Should this occur, large stands of increasingly dense cypress and bulloak would diminish broad biodiversity values and continue to exert pressure on the growth of canopy trees, particularly *Eucalyptus* species.

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 when plants and animals have become endangered.

The issue of increasing vegetation density is not currently being addressed in the State Conservation Areas, despite the *Brigalow and Nandewar Community Conservation Agreement 2009* permitting ecological thinning to meet specified ecological objectives.

Figure 15 illustrates the critical decisions that the NSW Government needs to make about the future of the State Conservation Areas. Business-as-usual management will not give us the greatest chance of achieving the best possible ecological and social outcomes in the Brigalow and Nandewar State Conservation Areas.

To change the potential trajectory of the cypress forests and ensure they support a greater variety of ecological outcomes through increased structural and floristic diversity, the NSW Government will need to adopt a new way of managing these areas.

In particular, managers need greater flexibility to apply appropriate interventions – such as ecological thinning and prescribed burning – within at-risk areas of the State Conservation Areas to meet specified ecological objectives that are consistent with the objects of the *National Parks and Wildlife Act 1974* (NSW).

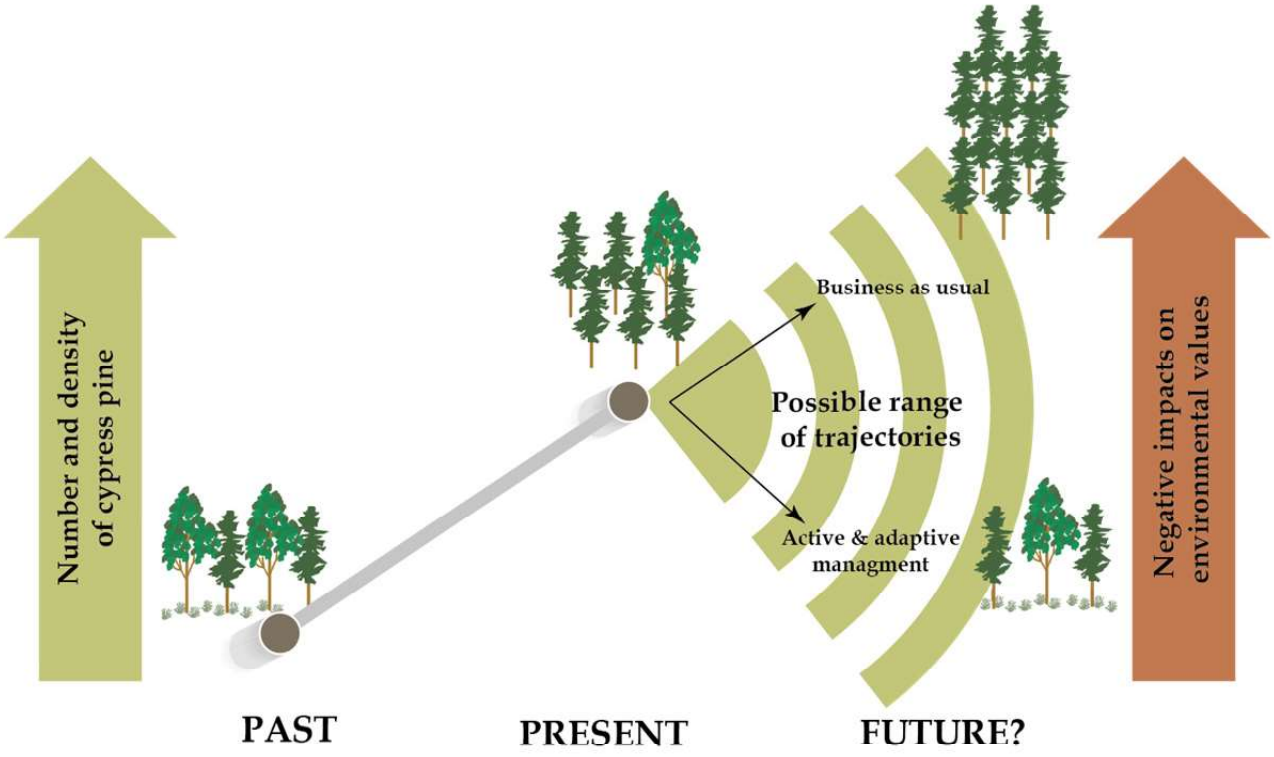


Figure 3: Scope for active and adaptive management to influence alternative futures and deliver desired ecological outcomes

2.1.3 Mapping current dense vegetation to inform management decisions

The NRC undertook spatial analysis to understand the current extent and distribution of dense vegetation, as well as forest structure and floristic diversity, in the State Conservation Areas. The spatial analysis within this report can help decision makers and land managers identify which areas are more likely to benefit from active management, and which areas may require a watching brief to monitor future landscape changes.

Based on this analysis, the NRC estimates that around 30,053 hectares (15 percent) of the total area of the State Conservation Areas has greater than 20 percent canopy coverage of cypress or bulloak. The NRC has also identified eight areas where a single stand of dense vegetation covers an area greater than 500 hectares. The largest areas of denser vegetation occur in Pilliga, Pilliga West and Trinkey State Conservation Areas, covering a total of 20,121 hectares.

Further, the NRC estimates nearly 40,000 hectares of the total area of the State Conservation Areas has greater than 10 percent canopy coverage of cypress or bulloak. Consistent with adaptive management, the NRC suggests these areas should be actively monitored to assess whether cypress and bulloak densities are increasing over time.

2.1.4 Management options

Large stands of increasingly dense vegetation should be actively managed using ecological thinning, ecological fire management and targeted grazing (if appropriate) to maintain or 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 areas of dense vegetation to improve ecological outcomes. In proposing these interventions, the NRC recognises that vegetation is one of the few biophysical elements that land managers can practically manage to maintain or enhance desired ecological outcomes.

In recommending ecological thinning, the NRC is not recommending commercial harvesting (or logging). Ecological thinning is the selective removal of trees or dense stands of vegetation for the primary purpose of achieving specified ecological outcomes. This is in contrast with commercial harvesting practices, where the primary focus is the promotion or extraction of merchantable timber. That said, ecological thinning may generate residues that have a secondary commercial value.

The proposed management interventions are consistent with practices already occurring on private land. Currently, cypress pine can be thinned or cleared as an invasive native species with certain prescriptions to maintain or 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. The NRC also advises that current pest and weed management practices should continue.

Table 1: Key active management interventions to manage dense vegetation

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 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 and black cypress pine on private or leasehold land to maintain or improve ecological outcomes under current 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 ▪ Large-scale thinning programs to restore habitat for flora and fauna have been use in for a long period in north American conifer 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 plant species to improve 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

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.

In some less-dense areas interventions may not be necessary in the short term, but a watching brief may be appropriate to monitor changes in the density and extent of vegetation over time. Under this watching brief, monitoring efforts could be targeted to focus on periods in which there are favourable conditions for cypress and bulloak regeneration.

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. Plans of management should identify ecologically appropriate intensities, frequencies and/or locations for each intervention option.

The proposed interventions, particularly ecological thinning and prescribed fire, have potential benefits and risks relating to carbon storage that need to be accounted for when developing management strategies. While the initial thinning or fire disturbance is expected to result in carbon release, these interventions can also stimulate growth of existing and new trees that can sequester carbon more rapidly than undisturbed forest sites. Further detailed carbon accounting would be required to ascertain the net carbon exchange for a proposed management intervention.

The NRC also recognises that some stakeholders have expressed concern about the risks posed by targeted grazing. The NRC is recommending that targeted grazing be available as a management option in the State Conservation Areas. However, its application should be informed by the current grazing trial currently underway in the south-western cypress conservation reserves.

2.1.5 Managing uncertainty and risk

The NRC acknowledges that there is scientific uncertainty around the structure and composition of the historical landscape, future trajectories, and around the most suitable management strategies for dense vegetation in the State Conservation Areas. While there is a significant knowledge base built up around the commercial management of cypress forests for economic values, there is less conclusive evidence around management of cypress forests for ecological outcomes within Australia.

These uncertainties should not prevent land managers from taking action to address identified landscape issues such as large stands of increasingly dense vegetation. Instead, the NRC recommends that active interventions be designed and implemented within an adaptive management framework. Adaptive management helps land managers consider and address the risks associated with interventions, and to improve management strategies over time. Active and adaptive management is explained further in the following section (**Section 2.2**), and **Chapter 6**.

2.2 Achieving better outcomes through new approaches

The Brigalow and Nandewar Community Conservation Area was intended to be a new land management tenure delivering coordinated, cross-tenure land management (NSW Parliamentary Debates - Legislative Assembly, 2005). However, in practice, the regulatory arrangements for the Community Conservation Area are still strongly linked to the existing regulatory framework for conservation and forestry tenure and management.

Plans of management guide management activities in the State Conservation Areas. These plans 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.[4]

Existing plans of management allow for management interventions to control pests and weeds, and to manage wildfires, but do not address impacts of dense vegetation or apply interventions within a best practice adaptive management framework. Management assumptions and strategies are not being fully documented and tested, and opportunities for learning and improving current management approaches are being missed.

Given these limitations, the current management approach to planning and management within the State Conservation Areas is unlikely to be delivering optimal ecological outcomes. A new way of understanding and managing these dynamic landscapes is needed if we are to sustain the ecological values associated with the State Conservation Areas in the face of changing environmental conditions and potential disturbances.

2.2.1 Implementing best-practice active and adaptive management

Traditional approaches to reserve management have not been able to address the complexity or uncertainties inherent in most natural systems. In response, contemporary natural resource management is shifting towards an active and adaptive approach to landscape management.

[4] Between May and June 2014, the Office of Environment and Heritage finalised statements of management intent for the remaining state conservation areas. These outline the basic management principles and priorities for these areas before a plan of management is developed.

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.

Adaptive management provides a good framework for actively managing the dynamic landscapes within the State Conservation Areas. This approach prompts land managers to better understand a broader range of existing and emerging landscape issues, and gives managers more flexibility as to how desired management objectives are achieved.

Importantly, land managers in NSW are already beginning to apply learning-oriented active and adaptive management approaches in other parts of the state, and there are many policy settings in place that support active and adaptive management in the State Conservation Areas. For example, 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.

2.2.2 New plans to implement active and adaptive management

An Adaptive Management Plan

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 a Ministerially-approved Adaptive Management Plan.

The Adaptive Management Plan should not be a technical document. Instead, it should set out at a high level the principles and processes for adopting an active and adaptive management approach across the State Conservation Areas.

As outlined in **Figure 4 – Step 03**, the plan should set the tone for the new management framework, particularly promoting adaptive governance and cross-tenure collaboration. In doing so, it will shift the focus back to the original intent of the Brigalow and Nandewar Community Conservation Area and ensure the area sets the national benchmark for innovative and genuine multi-use management.

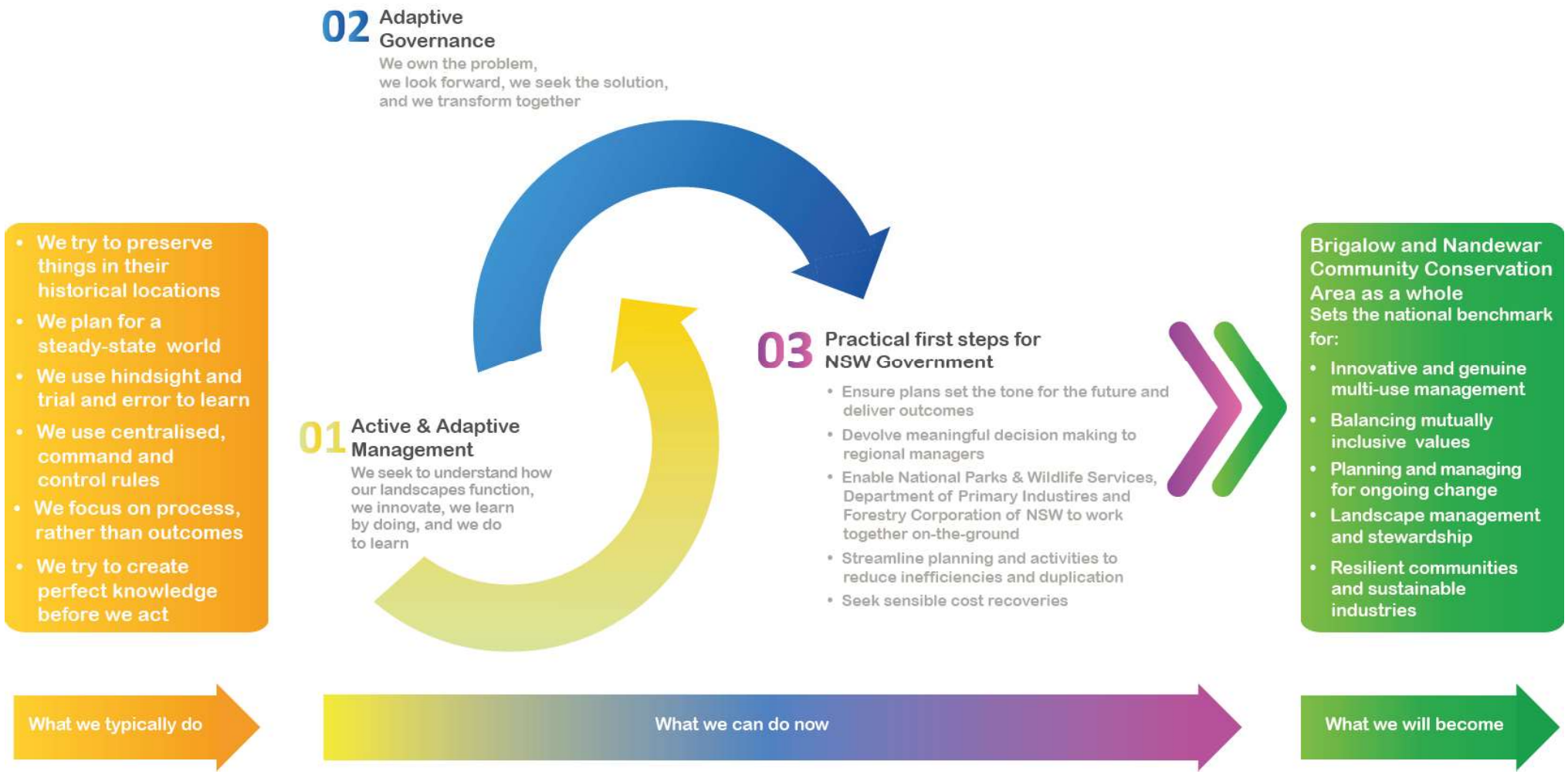


Figure 4: Model for adaptive governance and management, including active interventions

New or revised plans of management

Consistent with the Adaptive Management Plan, new or revised active and adaptive plans of management for the State Conservation Areas should be developed that include specific, measurable and spatially explicit management targets. These plans should contain finer scale management units nested within each state conservation area to provide land managers with greater ability to tailor and target management objectives and actions in individual areas.

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.

Further, the NRC recommends prioritising the development of plans of management for areas that have been identified as having the largest patches of denser vegetation: the Pilliga, Pilliga West and Trinkey State Conservation Areas. Plans of management for these areas should specifically address issues around increasing vegetation density in these large stands.

Government may also wish to prioritise the development of plans of management for areas that have had recent fire events, specifically to identify opportunities to actively manage post-fire regeneration. Recent fire events have occurred in the Goonoo and Pilliga East State Conservation Areas.

2.3 Exploring alternative funding and cost recovery models

Applying best practice active and adaptive management of cypress forests in the State Conservation Areas will incur additional costs over current management practices.

Given the finite resources available to manage public lands, the NSW Government and forest managers should explore alternative funding, cost recovery and cost sharing models for active landscape management to:

- more cost-effectively generate ecological outcomes
- improve long-term sustainability of management programs
- enable active management for ecological objectives to occur over a larger area
- deliver social and economic benefits.

With the exception of provisions for mineral exploration and extraction, the current regulatory framework for the State Conservation Areas treats economic and environmental values as mutually exclusive. This results in missed opportunities to deliver enhanced ecological outcomes through innovative funding arrangements.

Instead, in areas such as the cypress forests of the Brigalow and Nandewar State Conservation Areas, land managers should aim to find opportunities to achieve more cost-effective environmental outcomes through:

- cost recovery schemes
- goods for services schemes
- alternative funding sources.

2.4 Potential costs of an active and adaptive management program

The NRC has investigated the potential costs to the NSW Government associated with ecological thinning in the State Conservation Areas by modelling an example ecological thinning program and a range of cost recovery scenarios.

The NRC has modelled a five year program covering approximately 16,000 hectares in the Pilliga, Pilliga West and Trinkey State Conservation Areas. This area represents around eight per cent of the total area of the Brigalow and Nandewar State Conservation Areas, and excludes environmentally and culturally sensitive areas.

Under the NRC's modelled program, between 14,875 and 38,000 cubic metres of residues in the form of white cypress pine sawlogs could be generated over the five year period, depending on thinning intensity. The NRC recommends that Government seek to recover at least part of the costs of the modelled program.

Table 2 presents the NRC's cost estimates for the modelled program over five years for three cost recovery options:

1 no cost recovery

2 partial cost recovery

3 a goods for services scheme.

Table 2: Summary of cost estimates for modelled ecological thinning program

Option		Estimated cost for five year program (cost varies with thinning intensity)
1	**No cost recovery** Office of Environment and Heritage undertakes ecological thinning, retains residues on-site, and incurs all costs.	$3.85 – 7.1 million
2	**Partial cost recovery** Office of Environment and Heritage undertakes ecological thinning and removal of residues, sells residues to market and receives current equivalent market price for residues.	$2 – 2.5 million
3	**Good for services scheme** Office of Environment and Heritage engages contractor to undertake ecological thinning, including removing residues. National Parks and Wildlife Service incurs project management costs. Contractor bears the risk of seeking cost recovery through selling residues in the market place.	$0.95 – 2.5 million

The NRC recommends a goods for services scheme as the preferred option. Under a goods for services scheme, forest products are traded for services; in this case, ecological thinning to improve forest structure. Under this kind of scheme, there is potential for the NSW Government to incur only program management costs. The United States has been implementing a similar scheme with contracts and agreements since 2003.

The NRC notes that the actual costs and cost recovery achieved under the options outlined in **Table 2** will differ in practice, depending on the:

- ecological requirements, location and size of the areas being managed
- thinning regimes and treatment levels employed
- amount of residues with commercial value being generated in the areas being thinned.

In the future, there may be additional cost recovery opportunities associated with the use of ecological thinnings residues for electricity generation. Markets are developing for the use of biomass as fuel, though commercial opportunities are limited at present and there are legislative barriers at the state and national level.

2.5 Implications for local communities and industries

Active and adaptive management in the State Conservation Areas has the potential to provide minor socio-economic benefits to local communities. The magnitude of these benefits will depend on the location and extent of management activities, as well as the nature of any associated secondary commercial opportunities.

If commercial use of thinning residues is permitted, ecological thinning is likely to provide a minor economic benefit to local timber businesses, households and families, particularly in the communities of Baradine and Gwabegar. Any improvements in household employment, income and expenditure are likely to benefit Baradine and Gwabegar, as these towns are highly sensitive to changes in the timber industry.

The relatively robust, diverse regional economy and small size of any ecological thinning program in the State Conservation Areas mean these benefits are likely to be insignificant at a wider regional level.

2.6 Governance and accountability

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.

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
- an outcomes based performance audit model is used to provide accountability for active management programs, including ecological thinning programs.

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 for the Environment should also

seek advice from an independent reviewer before approving the overarching 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 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.

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 Legislative considerations

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

Table 3 sets out an analysis of active and adaptive management in the State Conservation Areas against ecologically sustainable development principles.

Table 3: Analysis of active and adaptive management in the State Conservation Areas against ecologically sustainable development principles

Ecologically sustainable development principles (Adapted from Section 3A of the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*)	Active and adaptive management in the State Conservation Areas
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 needs 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 improvements in ecological outcomes related to forest structure, floristic diversity and faunal habitat values.

Ecologically sustainable development principles (Adapted from Section 3A of the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*)	Active and adaptive management in the 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.

Legal advice indicates that under the objects of the *National Parks and Wildlife Act 1974* (NSW), residues generated from active management (such as ecological thinning) could be used commercially if the intervention was carried out for the primary purpose of delivering positive environmental outcomes. This means opportunities for cost recovery are likely to be legally permissible within the State Conservation Areas, provided they are a secondary consideration after the promotion of improved environmental, cultural and recreational outcomes.

The above legal advice is based on legal interpretation of the Act, and has not been tested through case law. Therefore, to provide greater certainty for active and adaptive management, the NRC recommends the following amendments to:

- the *Brigalow and Nandewar Community Conservation Area Act 2005* (NSW) to expressly allow ecological thinning in the State Conservation Areas (Zone 3) to deliver 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. It is also recommended that the NSW Government support the Renewable Energy Target Expert Panel's recommendation to the Australian Government on amendments to the *Renewable Energy (Electricity) Regulations 2001* (Cth) to recognise the use of ecological thinnings residues under the Renewable Energy Target.

To promote devolved decision-making and reduce administrative complexity, the *National Parks and Wildlife Act 1974* (NSW) should be amended to allow relevant National Parks and Wildlife Service regional managers to approve State Conservation Area plans of management.

3 Review overview

3.1 Terms of Reference

In a Terms of Reference (provided in full in **Attachment 1**), the Premier 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*.

The State Conservation Areas are shown in **Figure 1** and **Figure 2** and listed in full in **Attachment 2**. A separate booklet providing an overview of each of the State Conservation Areas has also been developed, and is available on the NRC's website.[5]

3.2 Defining 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[6] dominated by or associated with white cypress pine (*Callitris glaucophylla*[7]) and black cypress pine (*Callitris endicheri*) including woodland vegetation communities.

Although this review focuses on 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. In particular, stakeholders have identified bulloak (*Allocasuarina luehmanni*) as a species of potential management concern.

5 Available online at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx

6 A collection of plant species occupying a particular area.

7 Sometimes referred to as the eastern coastal cypress (*Callitris columellaris*).

3.3 Analytical framework and lines of evidence

The analytical framework for this review is shown in **Figure 5**.

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 **Section 5.5** 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.

The NRC also undertook:

- a public submissions process on the Terms of Reference, which generated 35 submissions (see NRC website for more details)[8]
- a public submissions process on the Draft Report, which generated 175 submissions (see **Attachment 5** for a list of submissions, **Attachment 6** for a summary of stakeholder feedback, and the NRC's website for access to submissions)[9]
- targeted consultation with relevant industry, Aboriginal, environment and community groups (see **Attachment 7** for a full list of stakeholder consultations)
- regional tours to visit the State Conservation Areas and other reserve areas within the Brigalow and Nandewar region (see **Attachment 8**).

8 NRC website for this review can be found at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx

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

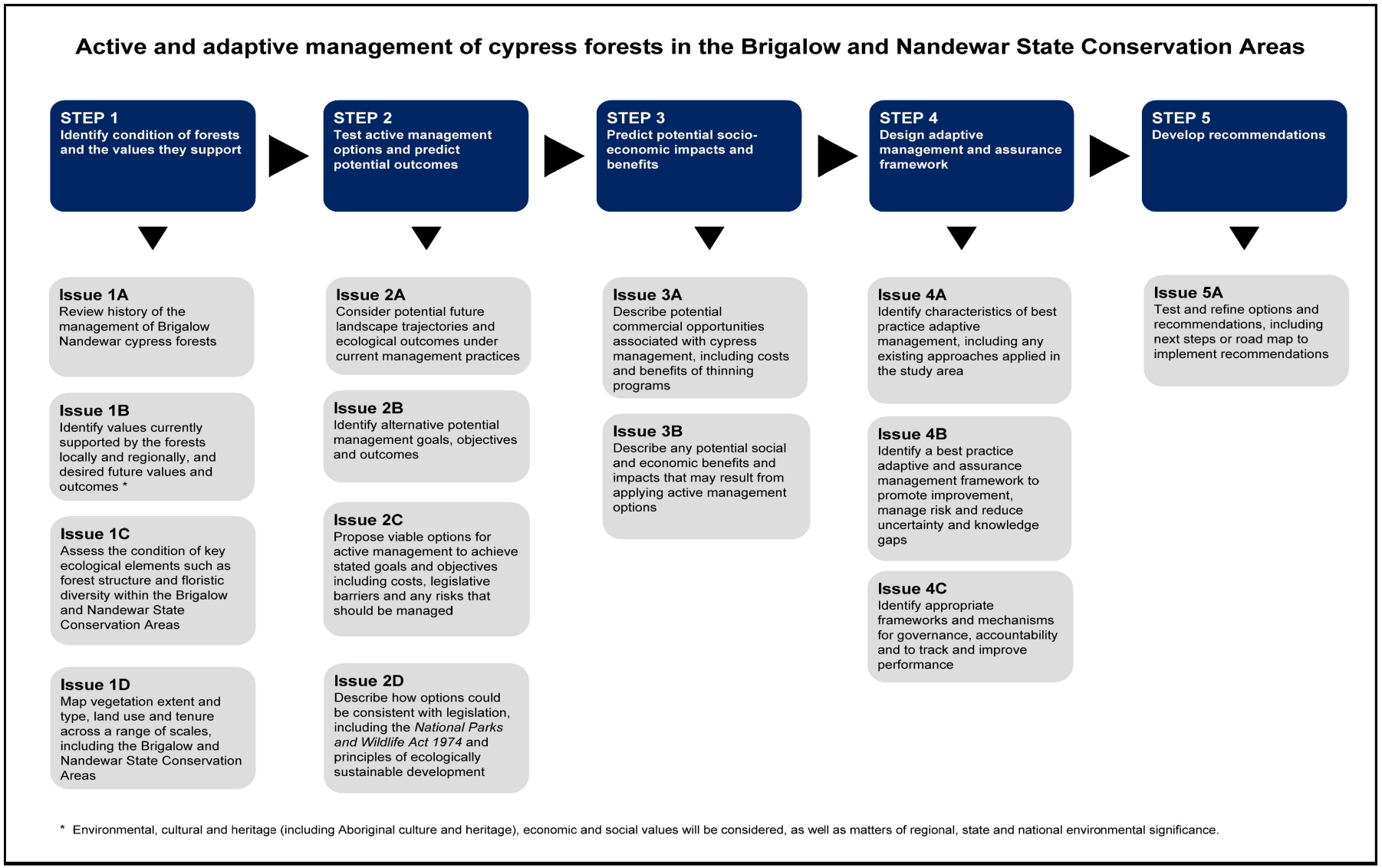


Figure 5: NRC's analytical framework

Part II – Managing differently to achieve better outcomes

4 Context and values of the State Conservation Areas

4.1 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) (refer to **Figure 1**).

The Brigalow and Nandewar Community Conservation Area was a novel initiative by Government to support multiple-use and cross-tenure land management (NSW Parliamentary Debates - Legislative Assembly, 2005). Existing reserve areas and state forests were allocated to new management zones (see **Table 4**) to be managed in consultation with the local community for a range of specific outcomes.

Table 4: Public land in the 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.

In practice, the regulatory arrangements for the Community Conservation Area are still strongly linked to the existing regulatory framework for conservation and forestry tenure and management. In effect, zones within the Community Conservation Area are managed no differently from other conservation and forestry tenures found elsewhere in NSW.

4.2 The Brigalow and Nandewar State Conservation Areas

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

Attachment 9 sets out a full list of relevant legislation, while **Chapter 11** provides more detail about the legislative requirements for active and adaptive management in the State Conservation Areas.

4.3 Landscape context

Figure 6 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 6**), while areas of irrigated cropping are found to the west of Moree (bright green areas in **Figure 6**).

In comparison, the State Conservation Areas (outlined in red in **Figure 6**) 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 6**).

There are two significant contiguous areas of vegetation:

- areas to the south-west of Narrabri, including the Pilliga, Pilliga East and Pilliga West State Conservation Areas
- an area to the north of Dubbo that includes the Goonoo State Conservation Area.

Most other reserves contain relatively small and isolated vegetation patches across the landscape.

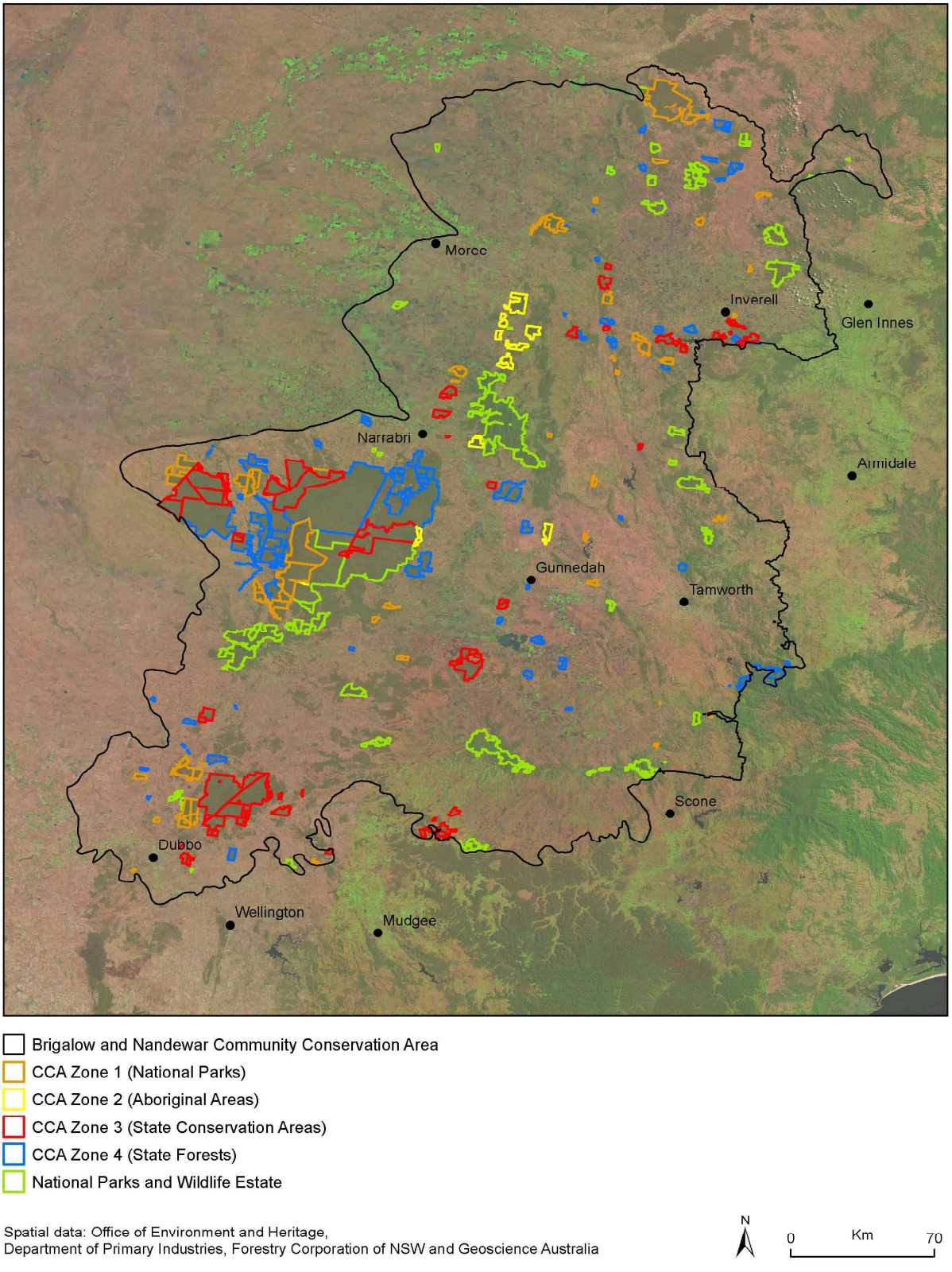


Figure 6: Landscape perspective of the assessment area

4.4 White cypress pine, black cypress pine and bulloak

As defined in **Section 3.2**, the term 'cypress forests' refers to all vegetation communities[10] dominated by or associated with white cypress pine (*Callitris glaucophylla*[11]) and black cypress pine (*Callitris endicheri*) including woodland vegetation communities.

White and black cypress pines are slow growing, coniferous native trees. Both species are drought tolerant, fire-sensitive and highly tolerant of crowding (Lacey, 1972; Zimmer et al., 2012).

Populations of white and black cypress pine can occur as co-dominants with various *Eucalyptus* species, or as the sole dominant species in other vegetation communities (Lindsay, 1967; Zimmer et al., 2012). The NRC estimates that of the 90 vegetation communities (NSW Vegetation Classification and Assessment) associated with the Brigalow and Nandewar State Conservation Areas, 56 contain white cypress pine as either the dominant or sub-dominant species (see **Attachment 10**).

White and black cypress pines are present in all of the State Conservation Areas to a larger or lesser extent, depending on preferred environmental attributes and historical disturbances. As a broad rule of thumb, white cypress pine is generally found more in the western region of Brigalow and Nandewar Community Conservation Area, whereas black cypress pine is found more in the eastern and southern regions.

There are many other plant communities within the State Conservation Areas that are also likely to benefit from improved management approaches. In particular, stakeholders have identified bulloak (*Allocasuarina luehmanni*) as a species of potential management concern.

Background information about white cypress pine, black cypress pine and bulloak is provided in **Table 5**.

10 A collection of plant species occupying a particular area.

11 Sometimes referred to as the eastern coastal cypress (*Callitris columellaris*).

Table 5: Key vegetation species discussed within this report

	White cypress pine	Black cypress pine	Bulloak
Scientific name	*Callitris glaucophylla* (also called the eastern coastal cypress - *Callitris columellaris)*	*Callitris endicheri*	*Allocasuarina luehmanni*
Height	Up to 25 metres.	Up to 15 metres.	Up to 15 metres.
Description	Grey-green foliage, conical tree, conifer species with seed cones.	Dark green foliage, conical tree, conifer species with seed cones.	Fine grey-green foliage, flowering plant, produces woody fruit similar to conifer cone.
Distribution	South-eastern Australia, ranging from central Queensland to Victoria, with extensive stands in most parts of central Queensland and NSW (Natural Resources Commission, 2010b).	South-eastern Australia, ranging from south eastern Queensland to north eastern Victoria (Harden, 1990).	South-eastern Australia through Victoria, NSW and southern Queensland (Anderson, 1968).
Soil types	Well-drained soils, common on sandy or loamy soils, and may be completely absent on heavy soils (NSW Industry and Development, 2014; Lindsay, 1967).	Well drained soils, particularly rockier, hillier sites that contain skeletal soils (Lacey, 1973).	Variety of non-calcareous soils, commonly on sandier soils (NSW Department of Primary Industries, 2010).
Ecological values and behaviour	Habitat, foraging resource and shelter for native birds and reptiles (NSW Department of Primary Industries, 2014; Natural Resources Commission, 2010b; Shelly, 2013; Paull & Date, 1999). Daytime roost for Koalas (Kavanagh et al., 2007). Lacks self-thinning mechanisms and can form dense stands and invade vegetation communities. Listed as an invasive native species under NSW native vegetation legislation.	Habitat, foraging resource and shelter for native birds (NSW Department of Primary Industries, 2014; Natural Resources Commission, 2010b). Lacks self-thinning mechanisms and can form dense stands and invade vegetation communities. Listed as an invasive native species under NSW native vegetation legislation.	Habitat, foraging resource and shelter for native birds, insects and orchids (Queensland Department of Environment and Heritage Protection, 2014a; Queensland Department of Environment and Heritage Protection, 2014b; L. Copeland pers. comm. 2014). Nitrogen-fixing species (Benson & McDougall, 1995). Dominant species in the endangered ecological community *Allocasuarina luehmannii* Woodland in the Riverina and Murray-Darling Depression Bioregions. Can behave in a weed like manner, and form dense stands.
Commercial use	Extremely termite resistant and very durable - managed as a commercial timber in central areas of NSW for over 100 years, common uses include: structural timber, external cladding, internal linings, posts and flooring (Natural Resources Commission, 2010b). Potential medicinal properties (Sadgrove & Jones, 2014).	Termite resistant, but less durable than white cypress pine (Doran & Turnbull, 1997). Has been used for fencing, general construction and as windbreaks and shelter for livestock (Doran & Turnbull, 1997), and also in veterinary and varnish products (NSW Department of Primary Industries, 2014). Potential medicinal properties (Sadgrove & Jones, 2014).	Bulloak has been used for roof shingles, flooring, furniture, fencing, wood turning, fodder, shelters for stock and firewood (Doran & Turnbull, 1997; Australian Government, 2014; Forabank, 2014; Marcar & Crawford, 2004).

4.5 Current values of the State Conservation Areas

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 6 describes some of the ecosystem services that could be provided within the State Conservation Areas.

Table 6: Ecosystem services that could be provided 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	

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.

Attachment 11 provides further information about specific values currently supported by the State Conservation Areas, including:

- **refugia and connectivity** - providing important refugia for native fauna and flora, and acting as nodes allowing organisms to move through native vegetation across the landscape
- **diverse flora and fauna –** high plant biodiversity and many native fauna species that are most abundant in the Brigalow and Nandewar region, including two reptile and seven mammal species that are found only in this area
- **threatened habitats and species –** supporting a range of flora and fauna that are listed as endangered under state and national legislation, particularly in eucalypt woodlands and vegetation types such as grassy woodlands, grasslands or semi-arid shrublands (see **Attachment 12** for full list of threatened species)
- **recreation values –** overall visitor and commercial tourism levels in the region are low, though some state conservation areas in the Brigalow and Nandewar region are used for recreational purposes, particularly the Pilliga and Goonoo, with visitation rates depending on accessibility to the conservation area itself or proximity to towns
- **research values –** some of the 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
- **Aboriginal cultural values –** forests within the region have traditional, historic and continuing cultural uses and meanings for Aboriginal people - they contain 276 registered Aboriginal sites (see **Attachment 13**), and are places in which skills, knowledge and traditions can be handed down, and where cultural education and training can occur
- **non-Aboriginal cultural values –** there are forty-two heritage items or places of historic heritage recorded in the State Conservation Areas (though no State Heritage items, see **Attachment 13**) **–** these are generally associated with past forest industries in the area
- **economic values –** the State Conservation Areas currently support industries such as mineral and petroleum exploration and extraction (see **Attachment 14**) and apiary, and many areas previously allowed for grazing and commercial forestry.

5 Managing dense vegetation in the State Conservation Areas

5.1 Exploring dense vegetation as a management issue

Large stands of dense vegetation in the State Conservation Areas within cypress forests – including white and black cypress and bulloak – are not addressed within current plans of management, but may be impacting on biodiversity in some areas.

Some 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 expressed concern about the impact of dense vegetation in the State Conservation Areas (NSW Government, 2013b). Other stakeholders suggest dense vegetation is a natural part of the landscape and therefore does not present a management issue.

To better understand this potential management issue, the NRC:

- reviewed the management history of the State Conservation Areas and resultant changes in forest structure
- used best available information to assess how dense vegetation may impact the current and future ecological values in these areas
- drew on new spatial analysis to estimate the extent and distribution of dense vegetation within the State Conservation Areas
- assessed whether there is a need to change the current management approach.

The NRC has determined that land managers need to identify and address likely impacts of large areas of dense vegetation within the State Conservation Areas through new and revised plans of management.

5.2 Past management history and changes in the landscape

An understanding of past management practices and their impacts provides useful context when exploring current landscape condition and values, and future landscape trajectories.

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 (**Attachments 10, 11 and 15** provide more detail on the diverse flora within these areas). At a finer scale, the structure, composition and values of cypress 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. **Figure 8** (**page 32**) provides an overview of the past landscape history of the Brigalow and Nandewar State Conservation Areas.

The NRC recognises 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 larger areas of open forest and tussock grassland (**Figure 7** shows an example of the latter)

(Croft et al., 1997; Jurskis, 2009; Lunt et al., 2006; Noble, 1993; Norris et al., 1991; Rolls, 1981; Ryan et al., 1995; Wyatt, 1989).

Factors influencing vegetation type and structure in the pre-European landscape would have included fire, light grazing by native animals and climatic influences such as droughts and seasonal rains (Horne, 1990). For example, 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 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).

Figure 7: Example of an open forest and tussock grassland in Beni State Conservation Area

Since European settlement in the 1800s, the Brigalow and Nandewar region has been intensively developed for agriculture (Benson, 1999; Curby & Humphries, 2002).

The 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). As a result, the current distribution of cypress forest is more fragmented than it was prior to European settlement, 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. As a result, the structure and composition of the cypress forests has therefore been influenced by past management for timber values, as well as the interaction of climate with grazing and fire events.

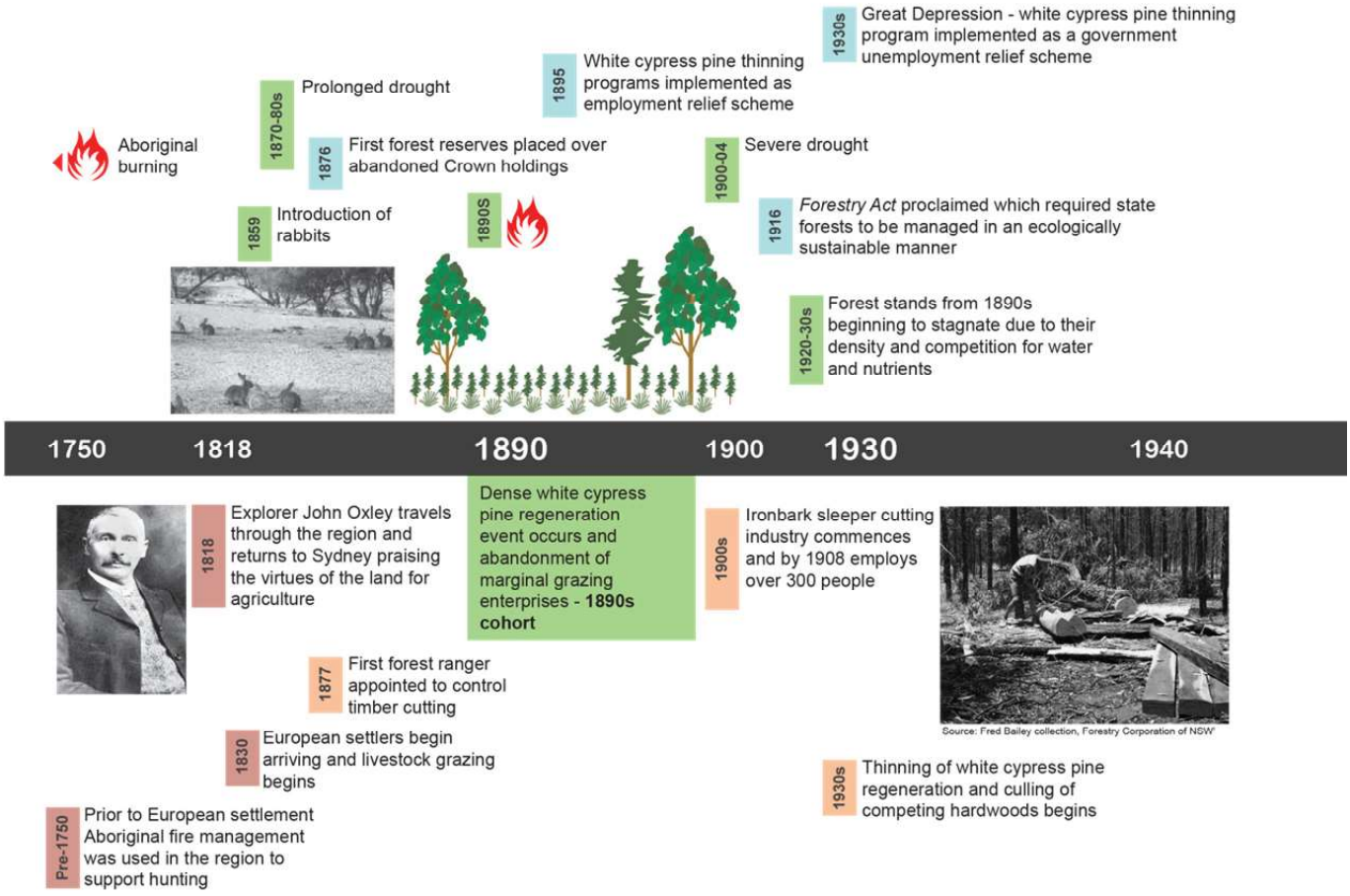


Figure 8: Landscape history overview for the Brigalow and Nandewar State Conservation Areas[12]

12 For more information on landscape history in the Brigalow and Nandewar State Conservation Areas see **Attachment 17**.

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

1957

1958

1951

Source: National Archives of Australia

1968 The Pilliga Nature reserve is established

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

Source: Forestry Corporation of NSW

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

2007-08

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

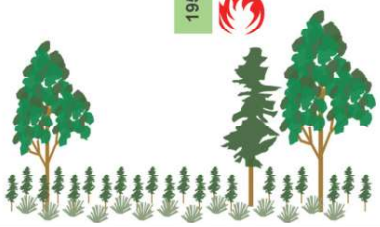
1997 140,000 hectares

1966

1974

1982

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



1950 | **1970** | **2000** | **2005** | **2013**

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

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

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

1980s Livestock grazing returned to State Forests under occupation permits

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

1950s Livestock grazing withdrawn from State Forests

Source: Fred Bailey collection, Forestry Corporation of NSW

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

2000 Ironbark sleeper cutting ends

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

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 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).

Multiple stakeholder submissions have provided anecdotal accounts of the expansion of dense vegetation in the landscape, including black and white cypress pine and bulloak. In some parts of the State Conservation Areas, the shift towards 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 cypress pine to become established.

Whipp et al. (2012) studied changes in the Pilliga forests over the last 60 years. This study focused on white cypress pine, bulloak and narrow-leaved ironbark (*Eucalyptus crebra*) and concluded that:

- in 2010, after a 60 year period, the mean density of all species within sample areas 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, with white cypress pine regeneration concentrated in stands with less competition from existing stands
- the increase in white cypress pine density was largely due to a regeneration event in the 1950s (Whipp et al., 2012).

The next section (**Section 0**) provides a more detailed discussion of the ecology and drivers of dense cypress and bulloak regeneration.

Generalised models of the likely structure, composition and function of Australian temperate woodlands in the Brigalow and Nandewar region before and after European settlement are included in **Attachment 16**. More information about the landscape history of the Brigalow and Nandewar State Conservation Areas is provided in **Attachment 17**.

5.3 Dense vegetation – ecology, drivers and thresholds

5.3.1 Cypress pine

Dense regeneration is a common feature of 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; Bureau of Rural Sciences, 2008).

There is a considerable amount of literature regarding the dense regeneration and encroachment of white cypress pine (BRS 2008), and less relating to black cypress pine. Some publications address both C*allitris* species, in which case it is difficult to separate information specifically related to white or black cypress pine.

White cypress pine regeneration

Figure 9 shows an example of dense white cypress pine regeneration.

Figure 9: Dense stand of white cypress pine regeneration

White cypress pine 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).

Lacey (1973) found vegetation density also affects the production of viable seeds in white cypress pine stands.

Figure 10 provides a generalised model of dense white cypress pine regeneration.

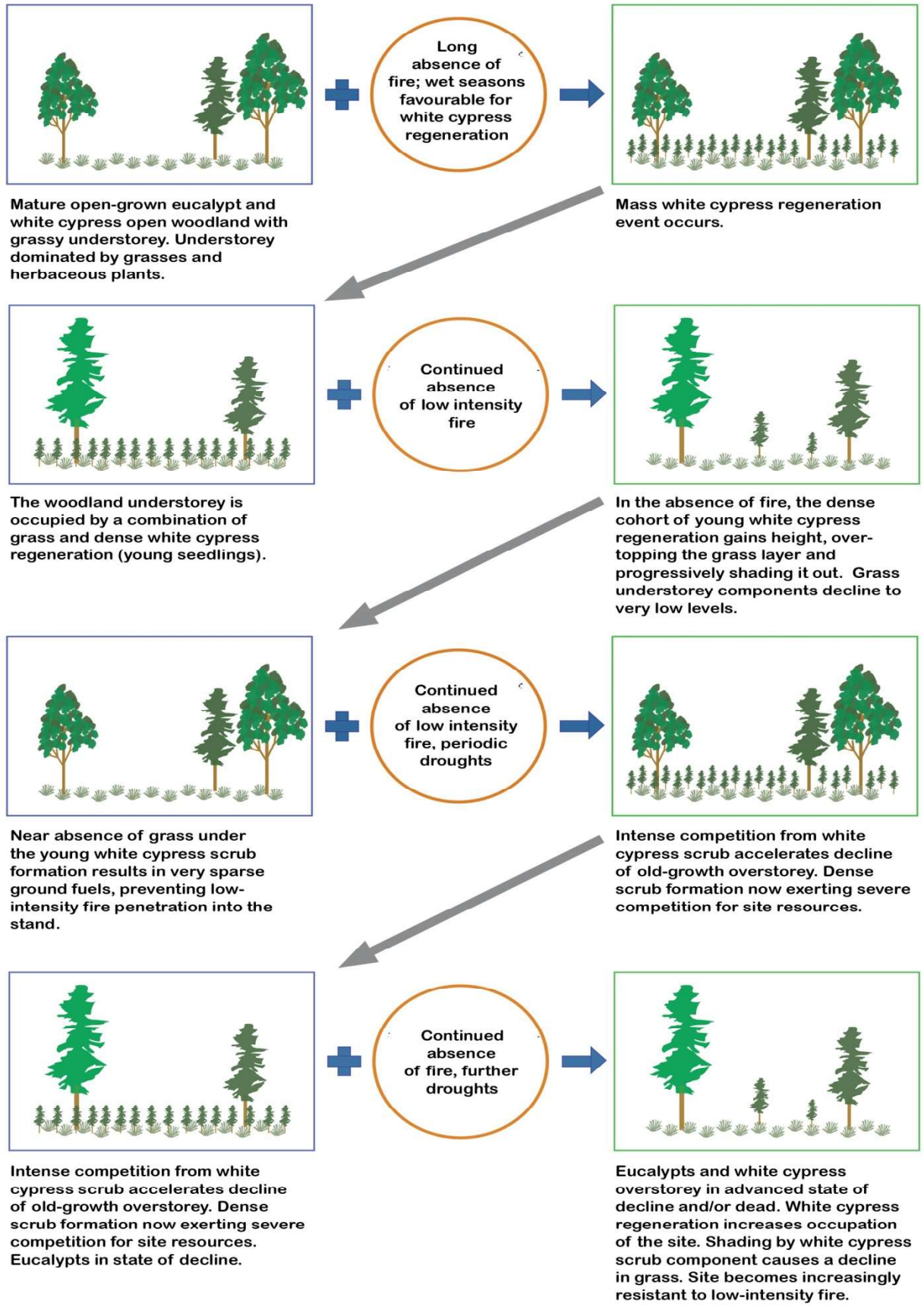


Figure 10: Generalised model of the structure and composition of Australian temperate woodland types with dense white cypress pine regeneration

White cypress pine regenerates more prolifically in open conditions with fewer competing plants (Horne, 1990). 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). The canopy of forests which are subject to silvicultural operations are, in general, both sufficiently open to allow for understorey growth and yet dense enough to suppress further regeneration episodes (Lacey, 1973).

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).

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
- lacks mechanisms for rapid self-thinning (Horne & Robinson, 1987; Knott, 1995; Lacey, 1972; Lunt et al., 2011).

In this 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).

Black cypress pine regeneration

There is little specific information available on black cypress pine regeneration. Kerle (2005) suggests black cypress pine regeneration can form dense thickets, but are considered less of a management problem compared to white cypress pine.

Seeds probably lack a dormancy mechanism (Greening Australia & CSIRO, 2014b; Benson & McDougall, 1995) and have inherently low germination rates (Doran & Turnbull, 1997).Black cypress pine seeds are more likely to germinate when sown into areas burnt by moderate and low intensity fires compared with unburnt areas (Knox & Clarke, 2006).

Similar to white cypress pine, significant regeneration events in black cypress pine are likely to occur with periods of high rainfall (Forestry Commission of NSW, 1988). Rainfall (particularly during establishment) and browsing are influential in the survival of all *Callitris* seedlings (Zimmer et al., 2012; Elsey, 1957). However, in the absence of fire, browsing pressure is the most important determinant of black cypress pine recruitment (Zimmer et al., 2012). High levels of browsing by rabbits, goats and native macropods substantially reduce the survival of black cypress pine seedlings.

Management options

Dense stands of white or black cypress can be managed using:

- prescribed fire to address early cypress regrowth (small stems)
- ecological thinning for more advanced regrowth
- targeted grazing (in particular circumstances, see **Section 8.4** for more details).

5.3.2 Bulloak

There is little detailed research on bulloak in NSW compared to studies undertaken in Victoria. Bulloak regeneration appears to be dependent on significant rainfall events (Macaulay & Westbrooke, 2003; Williams et al., 2004). Cheal et al. (2010) also note that regeneration events are linked with saturated soils associated with infrequent flooding. Otherwise there is little information on the interaction between various forms of disturbance and germination in bulloak.

Compared with cypress that regenerates only through seed, bulloak may also recruit by root suckering (Doran & Turnbull, 1997; Cheal et al., 2010), albeit less so than other *Casuarina* species (Cunningham et al., 1992). While bulloak rarely suckers in Victoria, there are anecdotal reports of comparatively minor soil disturbance caused by stock and machinery stimulating suckering of the species (Cheal et al., 2010). The degree to which suckering occurs on sites with or without soil disturbance in northern NSW remains unclear. The ability to regenerate by suckering impacts on the available management options, for example, ecological thinning is unlikely to be an effective management tool if thinned bulloak regenerates from the roots left in place.

Bulloak seedlings or suckers are less likely to occur when the tree canopy cover or biological crust exceeds 30 percent cover, or on bare ground lacking litter (Duncan et al., 2007). The closer transplanted bulloak saplings are to mature trees, the more likely they are to die (Morgan et al., 2013). This suggests that competitive interactions play a key role in sapling survival.

Rabbits and livestock may have a significant impact on recruitment (Cheal et al., 2010). Bulloak regeneration from seed or sucker is very low in the first 15 years after livestock is removed (Duncan et al., 2007).

Fire is likely to play a role in regulating populations of bulloak. Bulloak can be killed by fire, but can also recruit between fire events, either from seed or via suckers (Watson, 2007). For example, fire has probably maintained the open structure of bulloak woodlands in the Wimmera region of Victoria prior to European settlement (Macaulay & Westbrooke, 2003). Fire has also maintained boundaries between bulloak woodlands and communities that occur on similar soils (Cheal et al., 2010).

Due to its fire sensitivity, dense stands of small bulloak can be controlled with low intensity burns (Queensland Department of Environment and Heritage Protection, 2014).

5.3.3 Density thresholds

When discussing dense vegetation, it is important to note there is no agreed threshold to define dense vegetation within a reserve context.

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

- tree basal area[13] is greater than 18 square 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 cypress pine stands 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.

5.4 Ecological impact of increased vegetation density

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; Law & Dickman, 1997; Lindenmayer & Franklin, 2002; Lindenmayer et al., 2000; 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; Doherty et al., 2000; Law et al., 2011).

Large stands of woody vegetation can impact broad biodiversity values over time and space (Ayers et al., 2001; Carey & Johnson, 1995; Covington et al., 1997; Halpern & Spies, 1995; Noble, 1993; Sutherland et al., 2003). Further, dense woody vegetation is known to have a negative impact on canopy trees (Barnes & Archer, 1999; Callaway & Walker, 1997; Franklin et al., 1981; Noble, 1993). Woody vegetation increases competition for resources and can accelerate mortality of canopy trees (Belsky & Blumenthal, 1997; Covington et al., 1997).

In NSW, over forty native plant species are listed as invasive native species under native vegetation regulations, including eucalypt, acacia and cypress species (NSW Government, 2014a).

[13] 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.

Invasive native species are defined as:

"species [which are] densely regenerating or is invading plant communities in which the species does not generally occur, which is causing the decline in the structure or composition of the vegetation community."(NSW Government, 2014a)

Up to six vegetation formations have also been proposed as suitable for thinning under the native vegetation regulations (NSW Government, 2014b). Under the regulations, native species can be actively managed through interventions such as thinning and prescribed fire to maintain and enhance vegetation mosaics.

5.4.1 Potential impact of dense cypress pine

Impact of large, dense patches of cypress pine

There is debate around the impact of dense cypress pine on ecological values within the State Conservation Areas. While smaller stands of dense cypress within a vegetation mosaic support screening and habitat values, large stands of dense cypress pine that lack structural diversity may lead to negative ecological impacts. As in **Section 5.3.1**, the majority of research in this field centres on white cypress pine.

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). Drought affects eucalypts more severely than white cypress pine (Jurskis, 2011, 2009; Lacey, 1972). Further, 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 (Harris et al., 2003; Horne, 1990; Lacey, 1972; Bureau of Rural Sciences, 2008). 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[14] decrease most likely due to competition for resources such as space, nutrients, light and water (Hunter, 2013; McHenry et al., 2006; Harris et al., 2003). However herbaceous and non-vascular plants such as mosses, lichens and liverworts may increase under these conditions (Thompson & Eldridge, 2005b).

Other studies have challenged the 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; Andrews, 2003), 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 fewer social and recreational values than more floristically and structurally diverse areas of forest that provide favourable fauna habitat. Submissions from some regional community members stated that the condition of the forests have diminished in line with an increase in the extent and density of cypress and bulloak.

14 A plant that both obtains nutrients from its host and photosynthesises, such as mistletoe.

Other stakeholder submissions 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 numbers 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 list white and black cypress pine as invasive native species or as species that form part of a vegetation formation suitable for thinning (NSW Government, 2014a).

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). Under these regulations, dense cypress can be managed via clearing or thinning as a routine agricultural management activity.

Recent studies indicate that dense white cypress pine stands can provide screening for fauna against predation at the stand scale (Shelly, 2013; Eyre et al., n.d.) This illustrates the importance of retaining some stands of dense white and black 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.

Decline in eucalypts due to increased cypress density

Shifts from eucalypt to cypress-dominated vegetation communities have significant effects on the fauna that rely on eucalypts, as 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 soil 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; Shelly, 1998). Large trees, such as eucalypts, provide important ecological functions and have significantly declined in number since European settlement (Lindenmayer et al., 2012; Fischer et al., 2010). The loss of eucalypts in the same period is likely to have caused a major decline in nectar provision in some areas of NSW (Lunt et al., 2006). Previous studies in the Pilliga and Goonoo forests found low densities of hollow-dependent species, suggesting ecosystems are under stress (Resource and Conservation Assessment Council, 2002).

White cypress pine provides shelter among branches and bark for small birds, bats, invertebrates (Adams & Law, 2011; Law et al., 2011; Thompson & Eldridge, 2005b) and reptiles (Date & Paull, 2000), 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, 2003; Shelly, 1998).

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 of the State Conservation Areas (NSW National Parks and Wildlife Service, 2012b). 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).

5.4.2 Potential impact of dense bulloak

Bulloak can behave in a weed like manner, as it produces shallow 'root suckers' which can outcompete adjacent plants for nutrients (Australian Government, 2014). Dense bulloak regeneration has been described in areas of Victoria (Cheal et al., 2010) and NSW (Lindsay, 1967; Forestry Commission of NSW, 1988). Bulloak can form a lower tree layer of dense regrowth after disturbance, including after fire or timber harvesting (Benson et al., 2010)

Other *Allocasuarina* species (such as *A. littoralis* and *A. verticilata*) have been found to impact environmental values (Lunt, 1998; Kirkpatrick, 2004).

Whipp et al., (2012) recently found a three-fold increase in density and about a four-fold increase in total basal area of bulloak (along with white cypress pine and narrow-leaved ironbark) over 60 years in the central Pilliga region.

During this review, the NRC found stakeholders also expressed similar concern about bulloak in the State Conservation Areas. For example stakeholders suggested that:

- current forest stands in the State Conservation Area are not as healthy as in the past, with dense stands of white and black cypress pine and bulloak reducing biodiversity
- that the forests would benefit by removing woody weed undergrowth, including bulloak.

Other community members have expressed similar concerns in the past. For example, Downey (2008) reported that landholders in parts of the Namoi catchment expressed concerns over the invasive nature of bulloak on their properties, particularly when growing in combination with white cypress pine. In some cases, white cypress pine could not be treated effectively or economically by landholders under the native vegetation regulations as it grew too close to bulloak (which is protected under the native vegetation regulations) (Downey, 2008).

In 2008, the (then) Namoi Catchment Management Authority applied to the (then) Department of Environment and Climate Change to list bulloak as an invasive native species in the Namoi catchment management region (Downey, 2008). If listed, this would allow landholders to clear or thin bulloak to maintain and improve environmental outcomes. However, the application was rejected despite recognising that relatively dense stands of bulloak have been observed. The Department of Environment and Climate Change suggested that additional information regarding trends in thickening and invasive behaviour of bulloak should be established before bulloak could be regarded as an invasive native species.

5.4.3 Conclusion

The NRC supports the argument that some large stands of dense cypress pine should be actively managed to provide a more structurally and floristically diverse habitat mosaic within the State Conservation Areas.

The NRC considers that there is sufficient scientific and anecdotal evidence to suggest that dense stands of bulloak are also an emerging management issue. Large dense stands may impact ecological values in the State Conservation Areas both now and in the future.

Assumptions around the positive ecological impact of managing large areas of dense vegetation, as well as uncertainties around the optimum range of patch sizes for dense cypress pine and bulloak, should be tested within an adaptive management framework to reduce any remaining uncertainty and knowledge gaps around the active management of vegetation 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 stands of vegetation are within the State Conservation Areas. The results of this analysis are presented in **Section 5.5**.

5.5 Current extent and distribution of dense vegetation

The NRC undertook spatial analyses to generate new knowledge about the current extent, distribution and structure of dense vegetation in the State Conservation Areas, in particular the extent of dense white and black cypress pine and bulloak.

5.5.1 Identifying dense cypress pine and bulloak vegetation in the State Conservation Areas

In the past, decisions on dense vegetation management in the State Conservation Areas have been hampered by a lack of evidence around extent and distribution. To inform decision making, the NRC has used existing Digital Image Acquisition System (ADS40)[15] imagery to identify and map areas where there are likely to be more or less dense vegetation across all of the State Conservation Areas.

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 of the State Conservation Areas. This analysis allows for a complete census across the State Conservation Areas, rather than the traditional approach of describing vegetation characteristics from sample sites. Census avoids problems that are common in field assessments relating to sampling design and execution, inference, and error projections.

The NRC's initial spatial analysis targeted white cypress pine. However, during field validation it was found to also include black cypress pine and bulloak in some areas. This was due to the leaves of black cypress pine, and in some areas bulloak, having a similar reflective spectral signature as the leaves of white cypress pine. **Section 5.4** has described the ecological impacts associated with these three species.

[15] Digital Image Acquisition System (ADS40) is high resolution digital aerial photography collected using a second-generation airborne digital camera (Maguire et al., 2012).

The NRC used five nominal canopy density classes in the analysis (Classes 0 - 4), based on the percentage area covered by cypress pine, or in some areas bulloak, crowns.[16] **Figure 11** outlines the classes, and **Figure 13** shows on-ground examples.

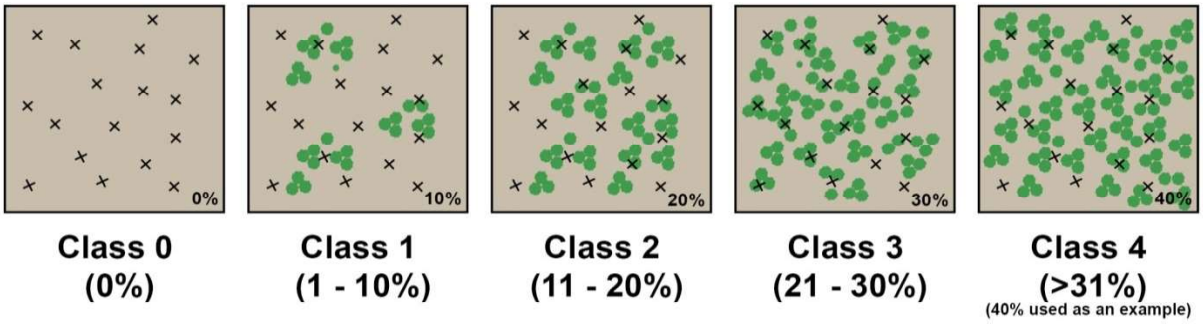


Figure 11: Illustration of the canopy density classes

Note: Green circles show indicative canopy percentage for cypress and/or bulloak. Black crosses represent other species. The spatial analysis used did not classify the canopy percentage for other species.

A step-by-step example of how the NRC used spatial data to arrive at canopy density classes is provided in **Figure 12**. Key stages in the analysis were:

- obtaining ADS40 data (**Figure 12 Map A**)
- creation of a continuous canopy density surface layer, which allows managers to see where vegetation is more or less dense (**Figure 12 Map B**)
- using the continuous canopy density data as the basis for categorising areas into canopy density classes to indicate the 'patchiness' of vegetation density (**Figure 12 Map C**).

The NRC is confident that these maps are a helpful tool for decision makers and land managers. By grouping cypress and bulloak into canopy density classes, managers can begin to identify larger areas of more dense vegetation within the landscape to help identify which areas are more likely to benefit from active management.

The canopy density classes derived by the NRC are a nominal starting point for initial analysis. Over time, the boundaries of these classes should be reviewed and revised as new information emerges during planning and implementation of management programs.

Further, the canopy density classes used in the analysis are only indicative of areas where stands of cypress and bulloak canopies are present at lower or higher density levels. This analysis cannot reliably predict attributes such as stem densities and basal area; to do so would require further survey stratification (for example, by forest type) and field sampling.

Lastly, this analysis cannot provide information about the total canopy cover of all species. In practice, these 'patches' of cypress and bulloak will exist within contiguous vegetation, rather than the more familiar discrete vegetation patches within a fragmented agricultural landscape. 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.

[16] 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 cypress pine or bulloak (each pixel represents 50 centimetres by 50 centimetres on the ground). The NRC allocated Class 4 (where cypress or bulloak density is greater than 31 percent) as the ceiling class, as there were only limited areas in State Conservation Areas where the density exceeded 40 percent.

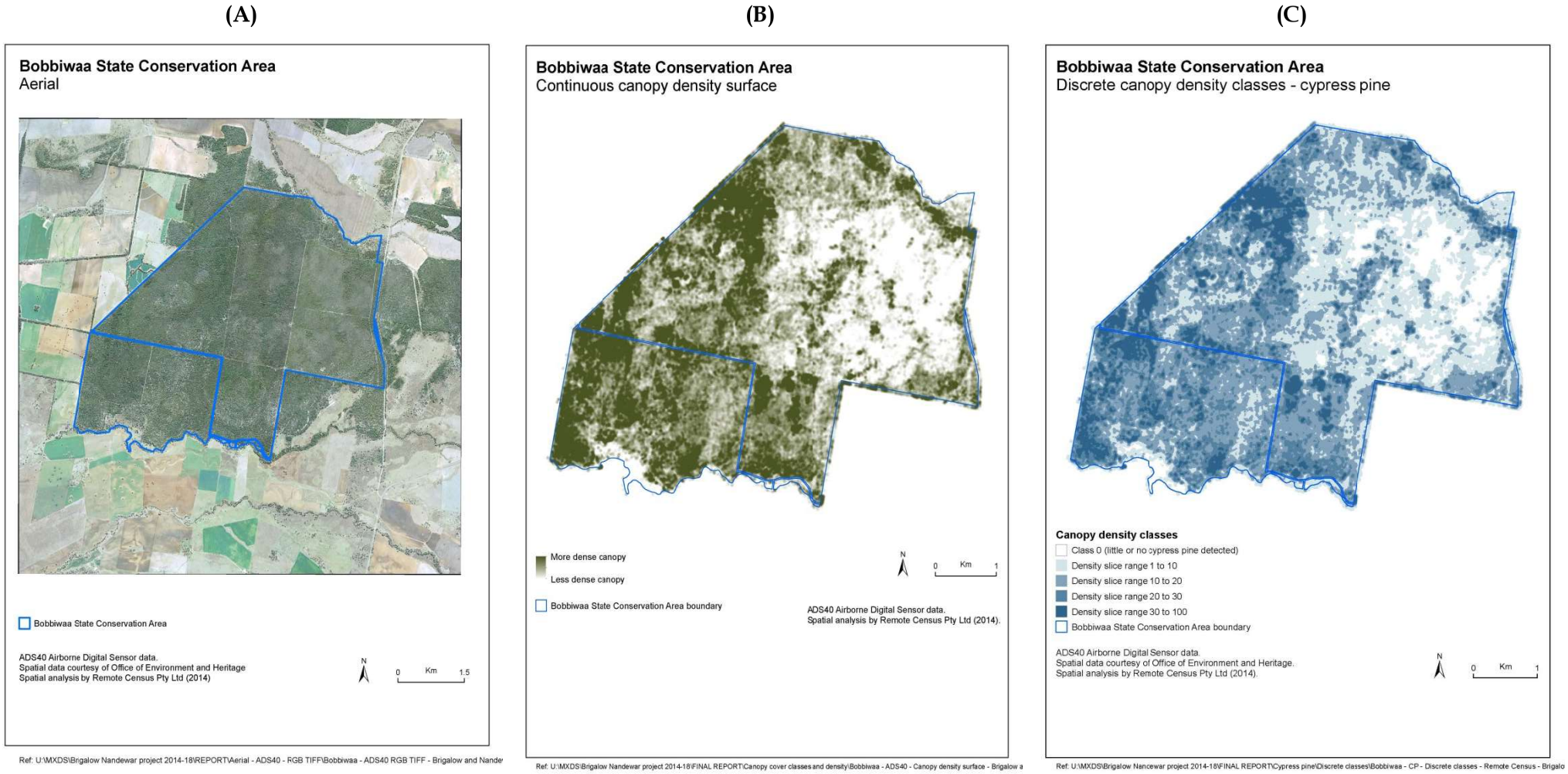


Figure 12: Steps in using spatial data to arrive at canopy density classes. Map A shows the original aerial photograph of the Bobbiwaa State Conservation Area based on ADS40 data. Map B shows the ADS40 data converted into a continuous canopy density surface, where darker areas represent more dense vegetation. In Map C, the NRC used the continuous canopy density surface in Map B to categorise the vegetation into five canopy density classes. In all maps, the darker areas contain relatively more-dense cypress pine (and bulloak in some instances) than the lighter areas.

Canopy Density Class 1
(Pilliga West State Conservation Area)

Canopy Density Class 2
(Merriwindi State Conservation Area)

Canopy Density Class 3
(Pilliga West State Conservation Area)

Canopy Density Class 4
(Pilliga West State Conservation Area)

Figure 13: On-ground examples of Canopy Density Classes 1 – 4

5.5.2 Separating out vegetation types

Modelling predicted locations of cypress and bulloak

White and black cypress pine are found in different areas due to their preference for particular biophysical attributes. For example, black cypress pine is usually found in rockier, hillier sites that contain skeletal soils (Lacey, 1973).

The NRC has modelled the predicted location of white cypress pine, black cypress pine and bulloak using existing vegetation mapping and other spatial datasets. An overview and breakdown of the location of white cypress pine, black cypress pine and bulloak for each of the State Conservation Areas is presented in the supporting map book, which is available on the NRC's website.[17]

Key findings from the predictive modelling (Eco Logical Australia, 2014a) include:

- white cypress pine and black cypress pine occupy distinctively different biophysical environments

[17] Available online at: nrc.nsw.gov.au/Workwedo/ActiveAndAdaptiveManagementOfCypressForestsInTheBrigalowAndNandewarStateConservationAreas.aspx

- bulloak can be found in vegetation communities that contain either white and/or black cypress pine (Benson et al., 2010), but overlaps more in areas predicted to contain white cypress pine rather than black cypress pine
- white cypress pine is more prevalent across the State Conservation Areas than black cypress pine, with bulloak occupying the least area of the three:
  - white cypress pine is more dominant than black cypress pine in 14 of the 23 Brigalow and Nandewar State Conservation Areas
  - black cypress pine is more dominant than white cypress pine in 9 of the 23 Brigalow and Nandewar State Conservation Areas
  - bulloak is not considered dominant in any of the State Conservation Area.

Table 7 provides a summary of the predicted distribution of each species, with examples of the State Conservation Areas in which these species are likely to be found.

Table 7: Predicted distribution of cypress and bulloak

Species	Predicted distribution within Brigalow and Nandewar region	State conservation areas with higher probability scores of occurrence
White cypress pine	Central-western and northern regions	Bingara, Bobbiwaa, Killarney, Merriwindi, Pilliga, Pilliga West, and Warialda State Conservation Areas
Black cypress pine	Southern, central-western and northern regions	Adelyne, Beni, Goodima, Durridgere and Goonoo State Conservation Areas
Bulloak	Central-western regions	Pilliga, Pilliga West, Merriwindi and Trinkey State Conservation Areas

The supporting map book also provides a breakdown of the predicted proportion of each species occurring in each of the State Conservation Areas. The map book also presents:

- the proportion of area covered by different Lindsay vegetation types (Lindsay, 1967) for each State Conservation Area
- a list of likely NSW Vegetation Classification and Assessment types (Benson et al., 2010) occurring in each of the State Conservation Areas.

Spectral analysis of bulloak

The initial spatial analysis undertaken to detect cypress pine also detected stands of bulloak in some areas, as the spectral signature from their leaves is very similar to that of cypress.

The NRC commissioned further research and development work to explore whether the ADS40 imagery could further distinguish between cypress species and bulloak. This required further processing and manipulation of the original ADS40 data used to detect, identify and classify cypress canopy densities.

The NRC found that bulloak could be identified and mapped with good levels of reliability if the original ADS40 imagery was of high quality. Conversely, the reliability of estimates was lower in areas where image quality was lower (see **Section 5.5.5** for discussion on reliability)

The NRC applied the same canopy density classes from the original analysis (see **Section 5.5.1**) to characterise and estimate the area of dense bulloak, the results of which are presented in **Table 8**.

Table 8: Estimated extent of bulloak canopy density classes

State conservation area	Area assessed - hectares (percentage of the state conservation area assessed)	Bulloak – area of each canopy density class – hectares (percentage of the state conservation area assessed)				
		Class 0 (<1 %)	Class 1 (1-10%)	Class 2 (11-20%)	Class3 (21-30%)	Class 4 (>31%)
Bobbiwaa	2,689 (100)	192 (7)	670 (25)	762 (28)	545 (20)	520 (20)
Killarney	1,857 (100)	5 (1)	321 (17)	832 (45)	469 (25)	230 (12)
Merriwindi	1,728 (100)	60 (4)	612 (35)	640 (37)	259 (15)	157 (9)
Pilliga West	16,276 (47)	637 (3)	3,521 (22)	3,693 (23)	2,940 (18)	5,485 (34)
Trinkey	6,489 (67)	649 (10)	2,269 (34)	1,354 (21)	949 (15)	1,268 (20)
Total	29,039	1,543	7,393	7,282	5,163	7,660

5.5.3 Findings from the NRC's vegetation density analysis

The results of the NRC's spatial analysis of vegetation density are presented in **Table 9** and **Table 10**.

The tables identify the:

- area of vegetation that falls within each canopy density class
- likely predominant species (white cypress pine, black cypress pine and bulloak) for each of the State Conservation Areas, based on the:
  - vegetation modelling presented in **Section 5.5.2**
  - Lindsay type mapping
  - NSW Vegetation Classification and Assessment (see map book for breakdown).
- the size of 'patches' occurring within classes 1-4.[18]

In some cases, the NRC's field surveys found vegetation species other than cypress pine growing in areas mapped as having areas of denser cypress canopy classes (see **Section 5.5.5**).

[18] The spatial methodology applied to group cypress pine into canopy density classes has in effect defined 'patches' of vegetation that contain cypress pine within the landscape. As such, these are 'patches' of vegetation containing cypress pine that exist within contiguous vegetation.

For example, *Acacia* regrowth was incorrectly identified as cypress in some of the canopy density classes in the Goonoo State Conservation Area. These areas correspond with areas that had been impacted by large wildfire events in the past. As such, the NRC has taken a conservative approach and excluded areas that have been affected by wildfire since 2004 from the area of estimated canopy density classes in **Table 9**. For example, over 26,000 hectares have been excluded in the Goonoo State Conservation Area.

However, the NRC notes that little-to-no cypress pine, or low canopy densities (Classes 0 and 1), were identified in areas impacted by wildfire events in Pilliga East State Conservation Area. Assuming cypress pine was burnt and removed in this event, this suggests the spatial data and methodology used in this area were robust.

Overall the NRC found that:

- over 50 percent of the total area across the State Conservation Areas contains little or no cypress pine, or low canopy densities (Classes 0 and 1)
- denser areas of cypress canopy (Classes 3 and 4) covered around 15 per cent of the total area of the State Conservation Areas
- the vast majority of discrete areas of a single canopy density class are less than one hectare, though these small patches only account for around 8 percent of the total area of cypress pine
- there are 62 patches of cypress in Classes 1-4 that are greater than 500 hectares in size and account for over half of the total area across all of the State Conservation Areas (54 percent)
- nearly all (over 99 percent) of the more dense classes (Classes 3 and 4) are found in patches less than 20 hectares in size.

There are eight patches identified as being within more dense vegetation classes (Classes 3 and 4) that are greater than 500 hectares (a total of 5, 725 hectares in total). These patches are found in Pilliga, Pilliga West and Trinkey State Conservation Areas.

Of these, Pilliga State Conservation Area has both the greatest area categorised as Class 3 and 4, as well as the most patches of Classes 3 and 4 over 500 hectares in size:

- one patch greater than 500 hectares with Class 4 canopy cover
- three patches greater than 500 hectares with Class 3 canopy cover.

Table 9: Estimated areas of canopy density classes for each of the State Conservation Areas

State conservation area	Canopy density classes (hectares) (excludes areas affected by wildfire since 2004)					All classes affected by wildfire (since 2004)	Likely predominate species (white cypress, black cypress or bulloak)		
	Class 0 (less than 1 percent)	Class 1 (1-10 percent)	Class 2 (11-20 percent)	Class 3 (21-30 percent)	Class 4 (greater than 30 percent)		NRC model	Lindsay types	NSWVCA
	Less dense canopy → More dense canopy								
Adelyne	4	45	67	59	27	-	Black cypress	Not typed	Black cypress
Beni	198	1,345	301	70	17	-	Black cypress	White/black cypress	All
Biddon	48	1,438	1,786	207	7	-	All	White cypress/bulloak	All
Bingara	146	875	678	315	113	-	White cypress	White cypress	White cypress
Bobbiwaa	304	888	941	475	213	-	White cypress	White cypress	White cypress
Bullawa Creek	1	63	46	11	1	-	White cypress	Not typed	White cypress
Cobbora	794	1,273	234	24	3	-	Black cypress	Not typed	All
Durridgere	2,680	2,826	970	301	216	-	Black cypress	Not typed	Black cypress
Goodiman	491	86	1	0	0	-	Black cypress	Not typed	Black cypress
Goonoo	4,887	13,649	3,171	2,635	1,142	26,786	Black cypress	Black cypress	Black cypress
Goonoowigal	130	635	383	61	3	-	Black cypress	Not typed	Black cypress
Gwydir River	82	827	620	272	145	1,782	White cypress	White cypress	White cypress
Killarney	11	503	742	487	224	-	White cypress	White cypress	White cypress
Leard	31	667	371	130	41	-	White cypress	White cypress	White cypress
Merriwindi	63	600	780	385	63	-	White cypress/bulloak	White cypress	White cypress/bulloak

State conservation area	Canopy density classes (hectares) (excludes areas affected by wildfire since 2004)					All classes affected by wildfire (since 2004)	Likely predominate species (white cypress, black cypress or bulloak)		
	Class 0 (less than 1 percent)	Class 1 (1-10 percent)	Class 2 (11-20 percent)	Class 3 (21-30 percent)	Class 4 (greater than 30 percent)		NRC model	Lindsay types	NSWVCA
	Less dense canopy → More dense canopy								
Pilliga	1,527	8,612	11,703	7,278	5,106	96	White cypress/bulloak	White cypress	White cypress/bulloak
Pilliga East	5,012	6,546	2,423	666	203	10,354	Black cypress	White cypress	Black cypress
Pilliga West	634	21,336	9,073	3,203	1,102	-	White cypress/bulloak	White cypress	White cypress/bulloak
Tingha Plateau	1,447	1,343	519	132	21	191	Black cypress	Mostly not typed	Black cypress
Trinkey	625	3,245	3,375	2,074	1,358	-	All	All	All
Warialda	76	1,087	1,080	579	295	-	White cypress	White/black cypress	White/black cypress
Wondoba	41	709	639	286	102	-	White cypress	Not typed	White/black cypress
Woodsreef	200	131	5	0	0	-	White cypress/black cypress	Not typed	White cypress
Total	19,431	68,729	39,905	19,651	10,402	39,209			

Table 10: Analysis of patch size (excludes areas impacted by wildfire events)

Patch size based on all canopy classes (hectares)	Less than 1	1-20	21-50	51-100	101-500	501-1000	Greater than 1001
Total area (hectares)	10,628	17,641	5,976	4,520	20,948	23,324	59,216
Number of patches	237,182	5,144	189	63	95	34	28

5.5.4 Assessing vegetation stand structure

The NRC has used LiDAR[19] data to analyse and describe stand structure and variability of vegetation across five of the State Conservation Areas.[20] 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.

The NRC considered that existing ADS40 data was sufficient for the analysis of canopy density. LiDAR analysis was therefore limited to five of the State Conservation Areas to reduce the costs associated with capturing new LiDAR data. The analysis only focuses on white cypress pine relative to other species in the stand.

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

- white cypress pine exhibits a relatively low cover and generally uniform height distribution, while non-cypress species have much higher cover and more variable height distributions
- there is little white cypress pine under 3 metres in height (sometimes referred to as cypress regrowth or regeneration)[21]
- 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 that 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.

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 supporting profile and map book.[22]

5.5.5 Reliability of the spatial analysis and next steps

The 'off-the-shelf' ADS40 imagery allowed the NRC to apply a consistent, objective and cost-effective dataset across all of the State Conservation Areas.

The confidence levels associated with the spatial analysis to detect and map cypress pine and bulloak in this review are shown in **Table 11**. These were arrived at by comparing field samples with image classifications and modelled estimates. Previous inventories of white cypress pine volumes across the Brigalow and Nandewar region using sampling techniques had an estimated confidence interval of plus or minus 30 percent (Baalman, 2003).

The creation of canopy density classes should be considered as a 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. Ideally, National Parks and Wildlife Service should leverage off existing

19 Light Detection and Ranging (LiDAR) is a technology that uses laser pulses to generate large amounts of data about the physical layout of terrain and landscape features (CSIRO, 2014).

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

21 This height band modelled as LiDAR data was not captured for trees below 3 metres.

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

spatial decision support tools within the NSW Office of Environment and Heritage such as Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) and Site and Catchment Resource Planning and Assessment (SCaRPA) to help model future scenarios and evaluate progress towards objectives.

While the ADS40 analysis represents a significant improvement on past approaches, there are some limitations, challenges and areas for further improvement. Image quality was the primary limitation. For example, some of the imagery varied in quality which has resulted in some over- and under-estimation of the presence, extent and canopy coverage of cypress pine and bulloak. In short, higher quality images improve the ability to detect cypress pine and bulloak with greater confidence.

Other limitations and improvements include:

- achieving improved separation between cypress pine, bulloak and other species such as belah (*Casuarina cristata*), rough barked apple (*Angophora floribunda)* and *Acacia* species within image classification
- providing stronger differentiation between eucalypt species to generate robust eucalypt to cypress pine ratios
- accounting for disturbances after the capture date of remotely sensed data.

Field surveys undertaken by the NRC have revealed some issues with the spatial analysis and subsequent maps. For example, areas indicating dense cypress canopy in the central regions of the Goonoo State Conservation Area are actually *Acacia* regrowth after wildfire events between 2004 and 2008. These areas have been identified in the mapping and excluded from the NRC's area estimates presented in **Table 9** and **Table 10**.

Nevertheless the NRC considers that the spatial data analysis approach used in this review is sound, and fit for purpose to meet the needs of the terms of reference.

Table 11: Reported accuracies and reliability of methods

Spatial analysis	Key measures and products	Confidence level[23]	Reference
ADS40 (~196,000 hectares)	▪ Cypress pine identification	**87 percent** (average)	(Eco Logical Australia, 2014b) (Attachment 3)
	▪ Cypress canopy percentage classes	**73 percent** (average)	(Eco Logical Australia, 2014b) (Attachment 3)
ADS40 (~29,000 hectares)	▪ Bulloak identification	**71 percent** (average) **50-100 percent** (range)	(RPS, 2014) (Attachment 3)

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

Spatial analysis	Key measures and products	Confidence level[23]	Reference
ADS40 + LiDAR (~29,000 hectares)	▪ Vegetation classification	**75 percent**	(Forestry Corporation of NSW, 2013) (Attachment 3)
	▪ Standing timber modelling	**90 percent**	(Forestry Corporation of NSW, 2014) (Attachment 3)

5.6 Potential future trajectories

The NRC's analysis characterises the extent and distribution of cypress pine and bulloak 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, some larger areas of cypress pine and bulloak have been identified that are at risk from the negative ecological impacts described in **Section 5.4**.

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 cypress canopies) will expand based on this analysis alone.

In practice, dense stands and patches of vegetation 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 changes.

However, recent studies suggest that the extent and density of white cypress pine has expanded, 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[24] 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."*

Whipp et al. (2012) also suggests that bulloak is encroaching in the Pilliga within a number of forest types, and is likely to continue in the absence of disturbance. However, this issue has received relatively little attention compared to white cypress pine (Whipp et al., 2012).

24 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).

Figure 14 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).

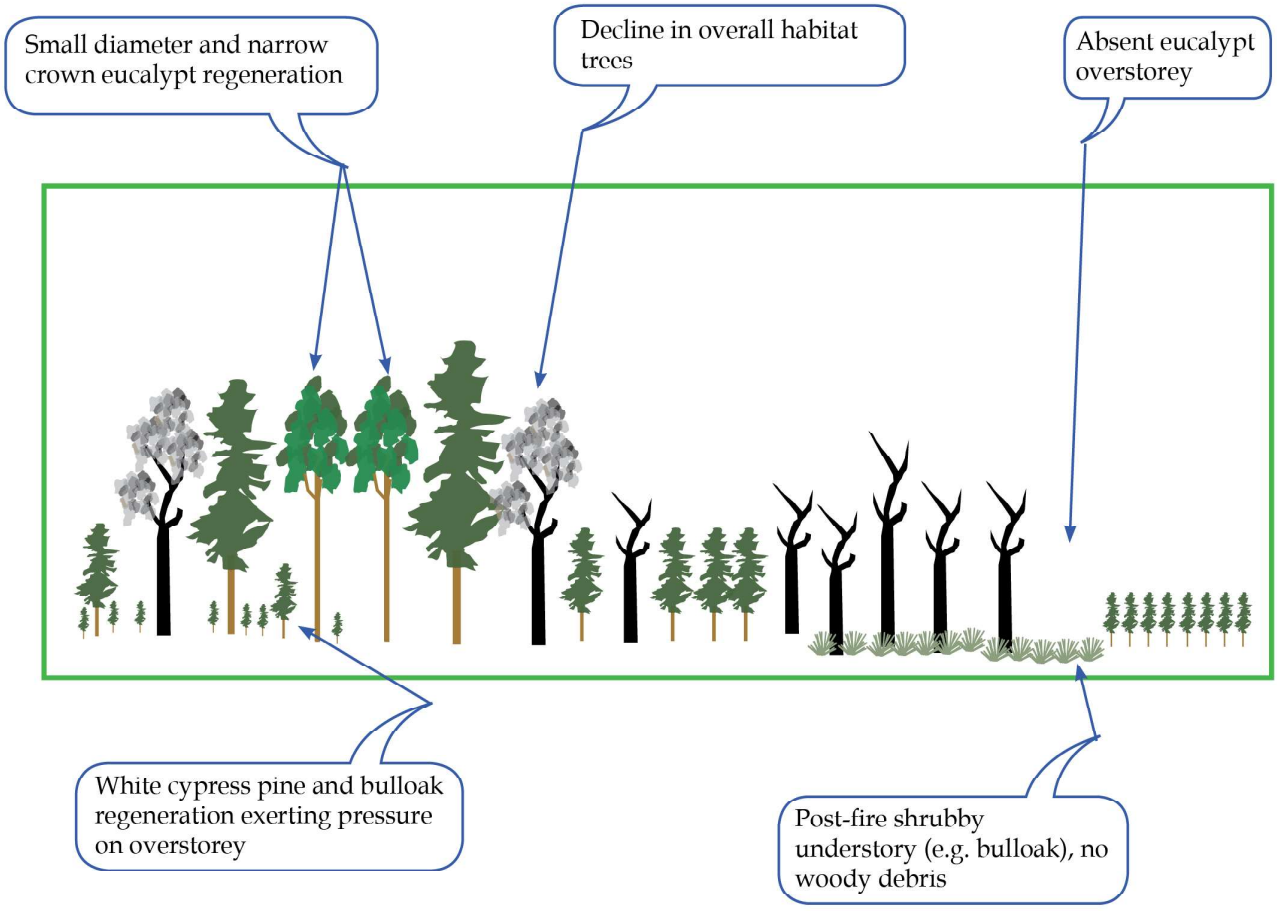


Figure 14: Indicative future state in a eucalypt-white cypress pine forest system

The full extent of the impacts of an increase in cypress pine density on environmental values in the State Conservation Areas will only be realised in time. For example, tree hollows can take up to 100 years to form; the same time 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 forests (Kerle 2005, after Allen 1998).

5.7 Managing dense vegetation for desired future outcomes

Based on the previous discussion within this chapter, **Figure 15** illustrates the critical decisions the NSW Government needs to make about the future of the State Conservation Areas.

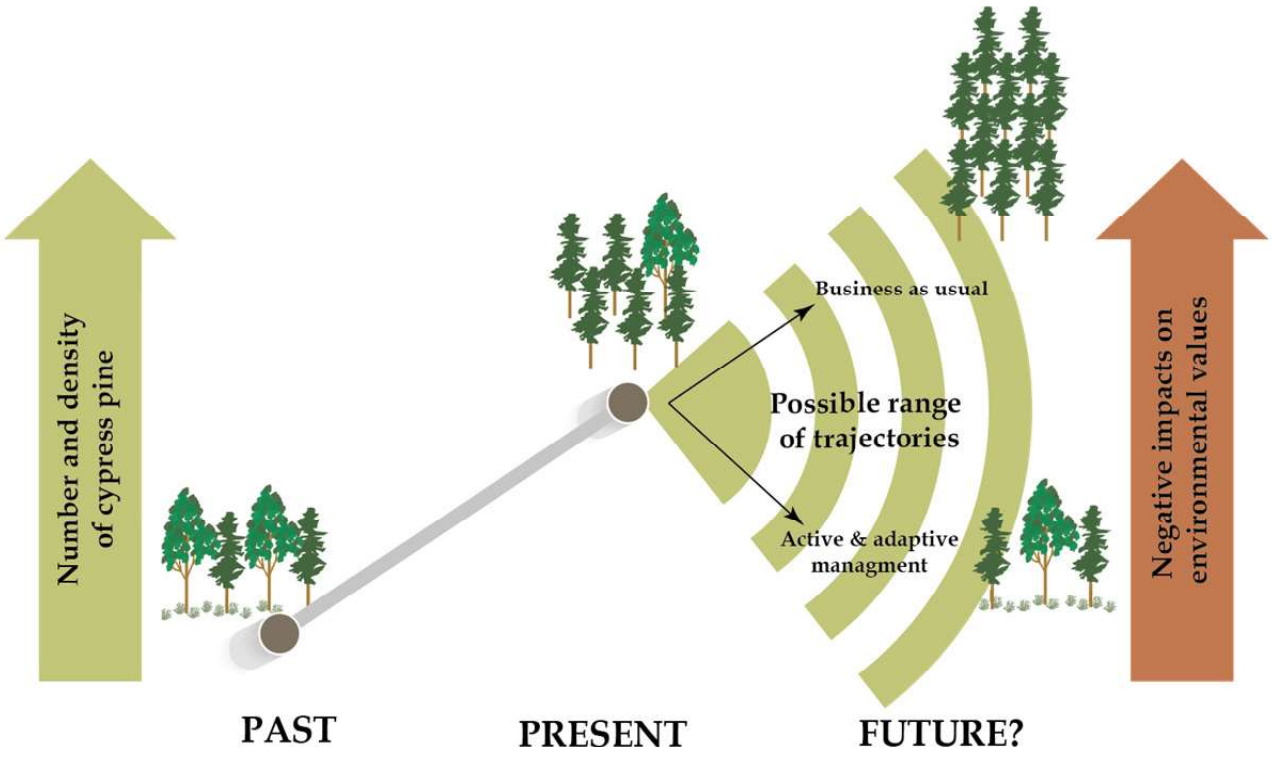


Figure 15: Scope for active and adaptive management to influence alternative futures and deliver desired ecological outcomes

Under the current management approach, the likely trajectory of these forests is that the density of cypress and bulloak vegetation will increase over time, and that ecological outcomes will be adversely impacted as a result.

Plans of management guide management activities in the 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 Brigalow and Nandewar State Conservation Areas (Biddon, Bullawa Creek and Leard), while a further two draft plans (Trinkey and Wondoba) have been released for public consultation.[25]

The existing plans of management do not address the potential for dense stands of vegetation to impact forest structural diversity and habitat values, nor potential issues around the change in the ratio of eucalypts to cypress pine within the canopy. If the current management strategies remain in place:

- management actions that promote increased cypress regeneration, such as fire reduction for asset protection, will continue
- interventions to manage dense vegetation (for example, ecological thinning) will continue to be excluded from plans of management, despite the *Brigalow and Nandewar Community Conservation Area Agreement 2009* providing for ecological non-commercial thinning to meet strategic management objectives.

25 See environment.nsw.gov.au/parkmanagement/ParkManagementPlans.htm (accessed 21 December 2013). Between May and June 2014, the Office of Environment and Heritage also finalised statements of management intent for the remaining State Conservation Areas. These outline basic management principles and priorities for these areas before a plan of management is developed.

Given the anticipated changes in vegetation density, business-as-usual management is likely to deliver less than optimal ecological and social outcomes in the Brigalow and Nandewar State Conservation Areas. Interventions are needed to change the potential trajectory of the cypress forests and ensure they support a greater variety of ecological outcomes through increased structural and floristic diversity. In short, the NSW Government needs to adopt a new, proactive way of managing these areas.

In particular, managers should be able to apply a wider range of appropriate interventions within at-risk areas of the State Conservation Areas to meet specified ecological objectives, consistent with the provisions of the *Brigalow and Nandewar Community Conservation Agreement 2009*.

Given the uncertainties around future trajectories and the most suitable management strategies for dense vegetation in the State Conservation Areas, the NRC recommends that any active interventions are managed within an adaptive management framework. More information about active and adaptive management is provided in **Chapter 6**.

The NRC is not suggesting that all parts of the State Conservation Area will require active intervention for vegetation management. However, land managers do need to:

- think more explicitly about potential landscape trajectories, alternative futures and desired ecological objectives
- set clear management goals and objectives linked to the identified ecological outcomes
- consider a wider range of management issues, including issues around dense vegetation
- have the flexibility to apply a range of active management tools to achieve desired outcomes, and the ability to trial new management approaches
- adopt an adaptive management approach that tests and evaluates management actions to improve management strategies over time.

As a first step, the NRC has considered potential management goals and objectives that could be used to improve the management of the State Conservation Areas, particularly the management of dense vegetation. The NRC has also developed a process model to identify potential management options. This model can be used to help identify areas that are likely to benefit from management interventions.

5.7.1 Revising the management goal for the State Conservation Areas

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

The *Brigalow and Nandewar Community Conservation Area Agreement 2009* sets out 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 and to support active and adaptive management, the NRC considers a suitable overarching goal for ecosystem management in the 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.

5.7.2 New management objectives for managing dense vegetation

Existing plans of management for the State Conservation Areas (NSW Office of Environment and Heritage, 2013c) 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 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 plant and animal 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 around dense vegetation identified in **Chapter 5**. These objectives, put forward in **Table 12**, 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 given its influence on other components of landscape health, including fauna populations, threatened species, soil health and water quality
- that vegetation is one of the few biophysical elements that land managers can practically actively manage to deliver ecological outcomes.

More specific, measurable and spatially explicit targets should be developed under these proposed additional objectives.

Table 12: Proposed additional management objectives for the 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 mid-storey and shrubs** Example of potential target: *Maintain the proportion of sclerophylloue mid-storey layer 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 larger, older 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** 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).*

5.7.3 Using process models to identify management options

Process models help identify potential management interventions that should facilitate the transition from undesirable to desirable states, to ultimately meet management goals (see **Table 13**, **element 3**).

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 plant and animal species (Duncan & Wintle, 2008; Spooner & Allcock, 2006).

Often the development of management objectives and process 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). Decision thresholds can trigger management actions and help land managers decide when to intervene to reduce costs or prevent irreversible damage (Cook et al., 2014).

As a helpful starting point, the NRC has developed a simple state and transition model (**Figure 16**) to help identify the active management options that can be used to achieve the objectives identified in **Table 12**.

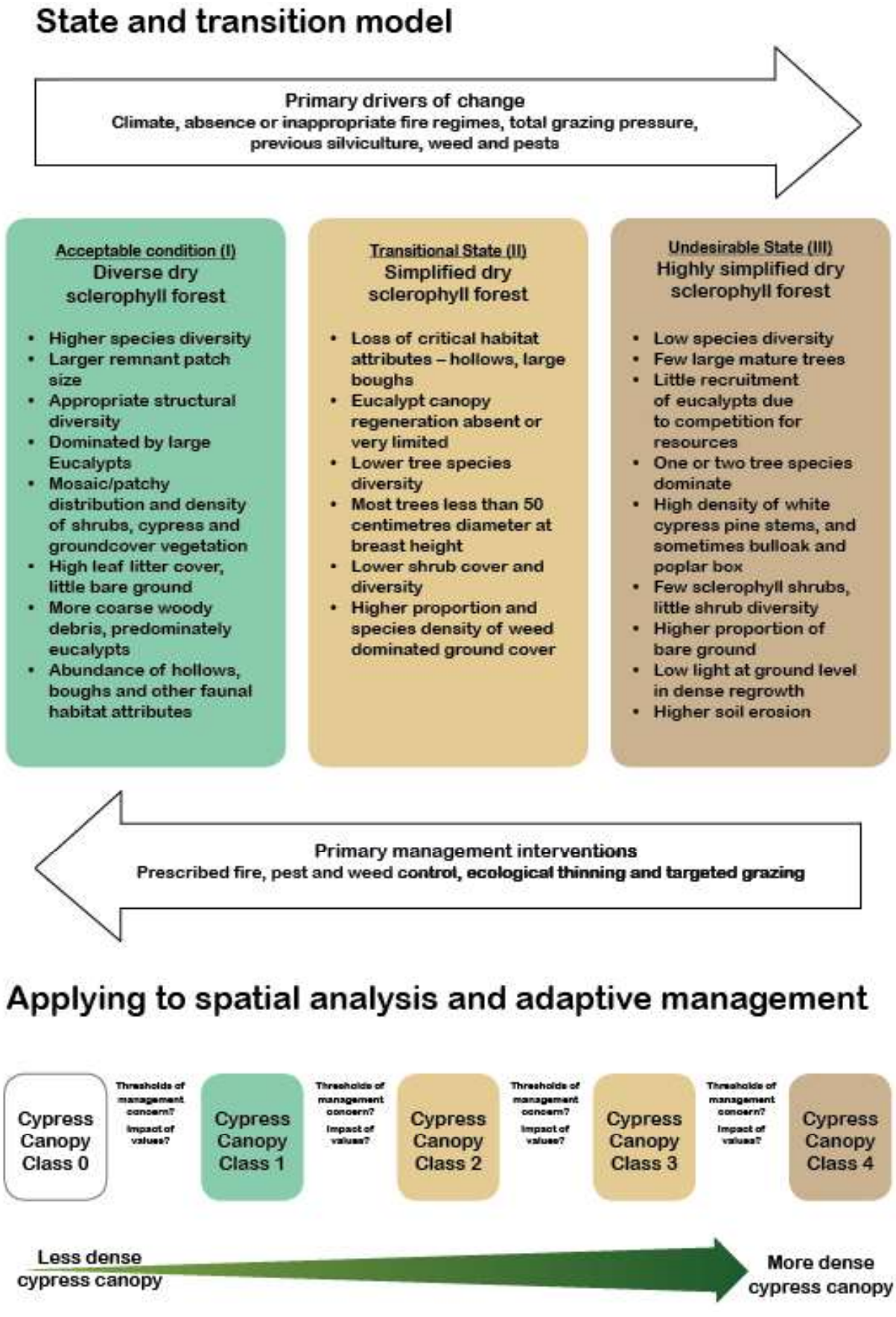


Figure 16: A state and transition model for cypress forests and associated woodlands showing potential drivers and management interventions for change

Based on this process model, the NRC recommends that ecological thinning, prescribed fire, targeted grazing and pest and weed control are made available as active management tools for State Conservation Area managers. Prescribed fire and pest and weed management are already being applied in the State Conservation Areas. More information about the potential management interventions identified above can be found in **Chapter 8**.

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 also consider implementing proactive monitoring in areas at risk of increases in vegetation density (for example, Class 2 areas), particularly when conditions are favourable for cypress of bulloak regeneration.

5.7.4 Using process models to identify priority areas for planning

Ideally, the National Parks and Wildlife Service should develop frameworks that link process models to specific, measurable and spatially explicit plans and targets. This would be similar to current state conservation area fire strategies, where spatially-represented fire thresholds linked to biodiversity values are used to guide future management.

For example, the canopy classes identified in the NRC spatial analysis for each of the State Conservation Areas (see **Figure 12**) could be aligned to the 'condition states' in the state and transition model shown in **Figure 16**. Based on this model, areas with higher cypress canopy density, as represented by Class 3 and Class 4, are more likely to correspond to an undesirable management state, and may therefore benefit most from active management.

The NRC considers these process models and canopy maps can be used as a practical starting point for land managers to explore and implement active and adaptive management, including defining thresholds between different states and exploring the impact of dense vegetation on ecological values. Although the canopy cover is highly variable across the landscape, these classes are a simple way of identifying areas that are likely to benefit from active management.

For example, the NRC's spatial analysis (presented in **Section 5.5.3**) identified Pilliga, Pilliga West and Trinkey State Conservation Areas as having the largest areas of denser vegetation (Class 3 and 4). Given the presence of large stands of dense vegetation, plans of management covering these areas should be developed as a priority, and should specifically address issues around increasing vegetation density in these large stands.

Further, areas with extensive stands of Class 2 cypress or bulloak may be a priority for monitoring changes in vegetation density over time, particularly following suitable conditions for regeneration events. For instance, Pilliga, Pilliga West and Trinkey State Conservation Areas also have extensive areas of Class 2 vegetation.

Finally, Goonoo and Pilliga East State Conservation Areas have significant areas affected by recent wildfire and post-fire regeneration. Government may wish to prioritise the development of plans of management for these areas, specifically to identify opportunities to actively manage post-fire regeneration (see **Section 8.5** for more details).

6 Achieving better outcomes through new approaches

6.1 Improving management in the State Conservation Areas

The Brigalow and Nandewar Community Conservation Area was intended as a new land management tenure supporting coordinated multi-use, cross-tenure land management with strong community input (NSW Government, 2009).

In practice, the regulatory arrangements for the Community Conservation Area are still strongly linked to the existing regulatory framework for conservation and forestry tenure and management. In effect, zones within the Community Conservation Area are managed no differently from other conservation and forestry tenures found elsewhere in NSW.

Some limitations of the current plans of management have already been identified in **Chapter 5**. For example, the management of dense vegetation and the potential to manage dense vegetation through ecological thinning are not addressed in the current plans of management, and no ecological thinning has occurred within the State Conservation Areas to date.

Further, while the current plans of management allow for pest and weed control, and bushfire management, these interventions are not being undertaken within a framework that supports active testing, learning and evaluation. Without a framework for understanding, documenting and testing management assumptions, opportunities for learning and improvement of current management approaches are being missed.

Finally, there is limited evidence of cross-tenure collaboration within the Community Conservation Area, despite Section 11 of the *Brigalow and Nandewar Community Conservation Area Agreement 2009* stating that land management agencies will work in partnership on common issues in Zones 1–4.

Given these limitations, the current management approach within the State Conservation Areas is unlikely to be delivering important ecological outcomes, such as an increase in the areas of mature eucalypt woodlands. A new way of understanding and managing landscapes is needed if we are to sustain the ecological, social, cultural and economic values associated with the State Conservation Areas.

The NRC recommends that the State Conservation Areas be managed in line with contemporary best-practice landscape management by formally adopting active and adaptive management.

6.2 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. Conventional conservation approaches assume that reserves are ecologically static and will retain their values through time with minimal intervention (Spooner & Allcock, 2006; Stankey & Allen, 2009; Stankey et al., 2005; Westoby et al., 1989).

In practice, these hands-off approaches are unlikely to deliver the best long-term ecological outcomes for the State Conservation Areas in the face of existing threats like pests and weeds, and emerging pressures such as climate change.

To address the limitations of traditional management approaches, contemporary natural resource management is shifting towards an active and adaptive approach to landscape management (Chapin III et al., 2009; Hobbs et al., 2011).

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.

6.2.1 Active management

Active management refers to intentional human interventions in a landscape to achieve desired environmental, social, cultural or economic objectives or outcomes (after Young, Petersen & Clary 2005). It usually focuses on processes, flows and feedbacks within a landscape system, as opposed to reactive approaches that tend to focus on isolated system components (Hobbs et al., 2011).

Many 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; Lindenmayer et al., 2014; Archibald et al., 2010; Attiwill, 1994). Well known examples of active interventions to restore ecological function and environmental values include river restoration (Bednarek, 2000; Shafroth et al., 2002; Kingsford & Biggs, 2012), eradication or removal of invasive fauna on offshore islands (PWS, 2014; Burbidge & Morris, 2002; Courchamp et al., 2003; Howald et al., 2007) and vegetation corridors in agricultural landscapes nationally (NSW Office of Environment and Heritage, 2014c) and overseas (Natural England, 2014).

In some cases however, fostering community support for active interventions within an adaptive management framework is important to gain both the social and scientific acceptance necessary for them to be applied widely (Archibald et al., 2010; Sydoriak et al., 2000; Attiwill, 1994). These can include controversial interventions such as the reintroduction of predator species into national parks (FWS, 1994; Halofsky & Ripple, 2008) and thinning native vegetation in conservation reserves (Archibald et al., 2010).

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, 2013a). 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, as well as human life and property (NSW National Parks and Wildlife Service, 2012a, 2013).

Nationally, other government agencies responsible for conservation reserves are undertaking active management to enhance ecological function and support environmental values. For example Garnett & Crowley (1999) and Neldner et al., (1997) found thickening stands of broad-leaved paperbark (*Melaleuca viridiflora)* in grassland ecosystems had reduced the numbers of endangered Golden-shouldered parrots in Queensland's Mungkan Kandju National Park in the 1920s and Lakefield National Park in the 1970s.

In response, the Queensland Government developed a recovery plan to increase the viability of the Golden-shouldered parrot in far north Queensland (Garnett & Crowley, 2002). Recovery actions include clearing dense stands of vegetation near nesting sites, prescribed burning to maintain and enhance open woodlands and control of invasive species to promote grass seeds for foraging. The plan requires a landscape approach, implemented in collaboration with traditional owners and pastoralists across a range of tenures (Garnett & Crowley, 2002, 1999).

Internationally, the United States and Canada are increasingly applying active management within forest landscapes (Stephens, 2013; Manning et al., 2012; Noss et al., 2006; Carey, 1991). For example, the United States' Forest Service is applying interventions in their forest production 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).

6.2.2 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; McDonald-Madden et al., 2010).

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; Archibald et al., 2010). As such, managers and decision makers often seek to understand events and management impacts through hindsight rather than proactively influencing the direction, scale and pace of change in real time (Griffith et al., 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 17**). 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).

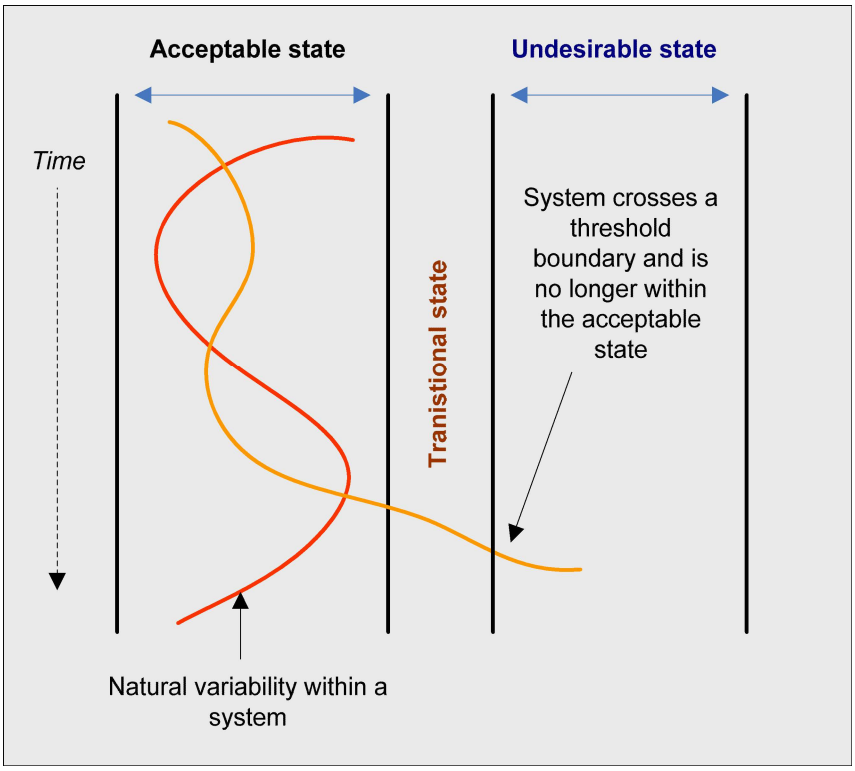


Figure 17: Conceptual model of systems dynamics containing key concepts such as acceptable and undesirable states and thresholds of concern (adapted from Central West Catchment Management Authority 2011)

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; Millar et al., 2007).

The framework presented in **Table 13** 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 13: 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 that 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 and implement management options	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.
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.

6.2.3 New management approaches in practice

Active and 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).

Contemporary thinking on adaptive management suggests it should challenge policy makers and managers to redefine their commonly held norms and protocols as a basis for changes in

governance and policies, rather than just continuous improvement within an organisation (Folke et al., 2009).

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 that successfully apply adaptive management.

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)[26]
- a grazing trial across the south-western cypress and river red gum reserves, due for completion in 2016 (NSW Office of Environment and Heritage, 2013b).

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).

6.3 A new management framework for the State Conservation Areas

Adaptive management provides a better framework for actively managing the dynamic landscapes within the State Conservation Areas. The historical and scientific debate around past and future landscapes in the State Conservation Areas, and around potential risks to environmental values from increasingly dense vegetation, demonstrates both the need and an appropriate context to apply these new approaches.

26 Plots will be monitored annually for first five years, then surveyed every five years thereafter

Active and adaptive management prompts land managers to better understand a broader range of existing and emerging landscape issues, and gives managers more flexibility as to how desired management objectives are achieved.

Importantly, adaptive management also provides a way of managing the risks associated with undesirable future landscape trajectories, and the risks associated with any active management interventions. By explicitly considering the benefits and risks of different management interventions, managers can confidently apply a broader range of intervention options to accelerate the rate of progress towards desired landscape outcomes.

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, 2013). 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 14 describes the key policy conditions that suit adaptive management, and explains its relevance for the Brigalow and Nandewar State Conservation Areas.

Table 14: Key policy conditions for the application of adaptive management and relevance to the 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 benefits from a range of proposed additional active management options in the State Conservation Areas are uncertain, hence the need to test and adapt management strategies over time. 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.

Conditions for adaptive management (after Craig & Ruhl 2014)		Relevance to Brigalow and Nandewar State Conservation Areas
Policy makers and managers have the capacity to monitor and evaluate, a strong culture of learning and reflection, and the ability to 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, as well as 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.
	✓ / ✗	Stakeholders generally support adaptive management, although support for specific active interventions, particularly ecological thinning, that may be applied as part of adaptive management of the State Conservation Areas is mixed. Stakeholders have also expressed diverse views on seeking cost recovery by allowing secondary commercial benefits to be obtained from active and adaptive management programs.

Implementing best-practice active and adaptive management for the Brigalow and Nandewar State Conservation Areas 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 NRC cautions that 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 and processes such as detailed, upfront pre-decision impacts assessments and intense public consultation models (Craig & Ruhl, 2014).

6.4 New plans to deliver better outcomes

6.4.1 Developing an Adaptive Management Plan

The NRC recommends that the Office of Environment and Heritage develops an Adaptive Management Plan that will apply across all state conservation areas in the Brigalow and Nandewar Community Conservation Area.

The Adaptive Management Plan should be informed by the principles of adaptive management, including the adaptive management framework provided in **Table 13 (page 66)**. However, it is not intended that this plan be a technical document. Instead, it should set out at a high level the principles and processes for adopting an active and adaptive management approach across the State Conservation Areas.

As outlined in **Figure 18 – Step 03**, the plan should set the tone for the new management framework, including clearly identifying:

- devolved decision making arrangements
- how the adaptive management framework should be applied
- a high-level understanding of landscape function and potential management options
- how collaboration will be facilitated
- opportunities to reduce inefficiency and duplication
- principles to guide cost recovery.

The Adaptive Management Plan should shift the focus back to the original intent of the Brigalow and Nandewar Community Conservation Area, by ensuring the area sets the national benchmark for innovative and genuine multi-use management.

In particular, the Adaptive Management Plan should promote adaptive governance, including cross-tenure collaboration to align with new practices encouraged within NSW Government (NSW Public Service Commission, 2014).

Adaptive governance is a concept linked to the adaptive management approach and, as such, is also at the forefront of contemporary scientific thinking for conservation and natural resource management (see for example, Marshall, 2008; Chapin III et al., 2009).

Adaptive governance suggests that institutions and decision making need to be arranged so they can readily adapt in the face of uncertainty and change, and effectively deal with a range of different values, interests, perspectives and knowledge (Griffith et al., 2014). Put simply, governance should be designed to focus on outcomes and 'help communities to help themselves' (Griffith et al., 2014). It is likely the greatest opportunities for active interventions will be those focused on changing the way people think and act – the way information transfers between us, the way we make our rules, and the paradigms we construct around the way we conserve biodiversity and manage our natural resources (Meadows, 2008).

Governments are now moving towards governance arrangements that transfer decision making to the scale where issues are best understood by government and communities, and where both can navigate towards solutions through innovation, co-learning and adaptation. This is reinforced within the *NSW 2021* state plan (NSW Government, 2011). This shift towards greater devolution and collaborative management recognises centralised, top-down governance arrangements cannot adequately deal with complex conservation and natural resources management issues, particularly through prescriptive rules and 'one-size-fits' all standards (Gallop, 2006; Bartlett & Packer, 2008).

The Adaptive Management Plan should be developed with input from the Forestry Corporation of NSW, Department of Primary Industries and Local Land Services, and should facilitate cross-tenure collaboration. For instance, it should help planners seek opportunities to align common management actions and objectives, and identify potential areas and issues for collaborative monitoring and evaluation. As a practical first step, the NRC is recommending a Regional Officers Working Group be established to facilitate cross-tenure collaboration between land managers at the operational scale (see **Section 11.3** for more details).

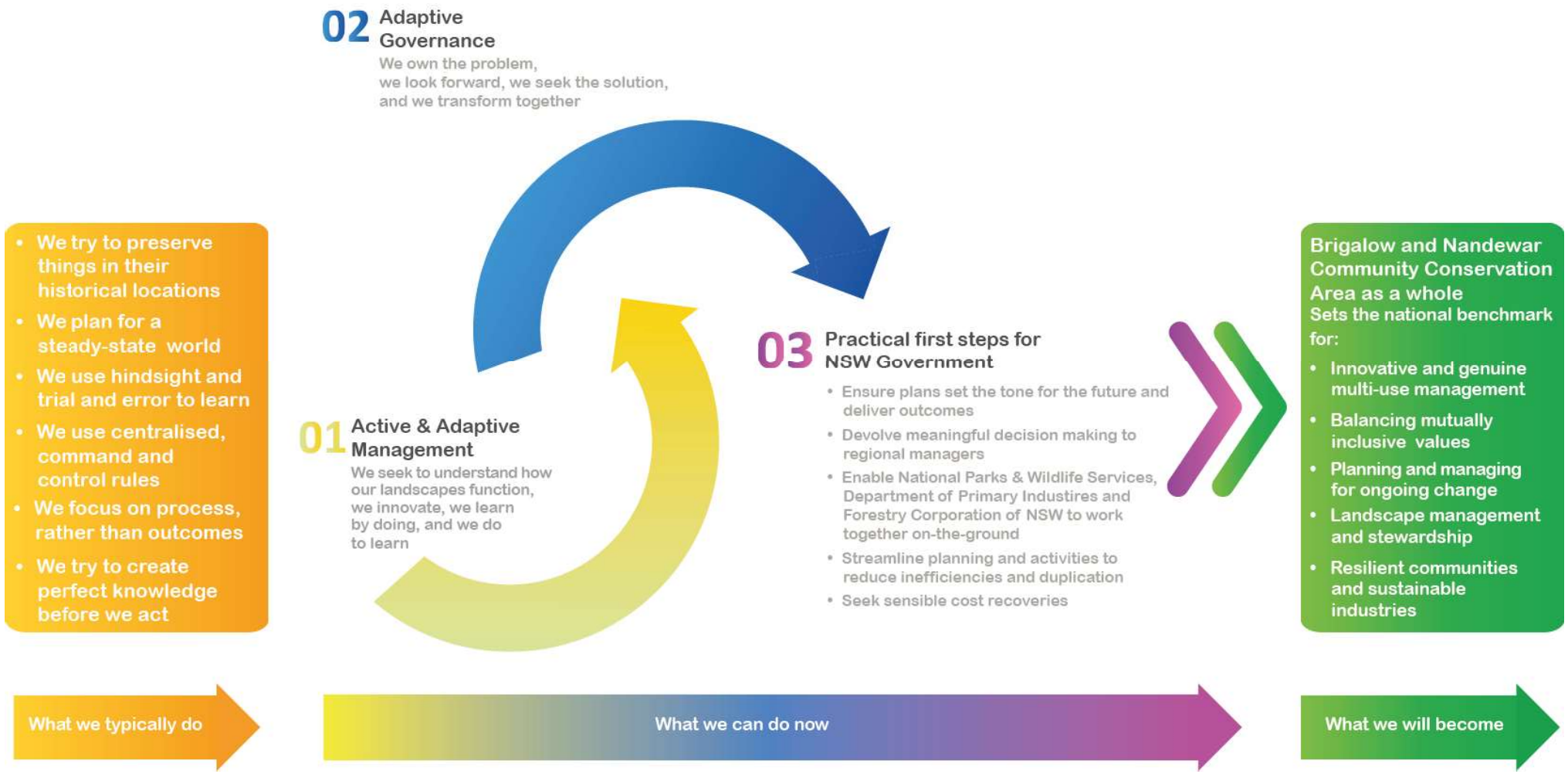


Figure 18: Model for adaptive governance and management, including active interventions

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.

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 its 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.

Further details around governance, accountability, monitoring and evaluation for the Adaptive Management Plan are provided in **Chapter 11**.

6.4.2 Developing new and revised plans of management

Guided by the Adaptive Management Plan, the Office of Environment and Heritage should develop new or revised plans of management for each of the State Conservation Areas in a timely manner.

In particular, in **Section 5.7.4** the Pilliga, Pilliga West, Trinkey State Conservation Areas were identified as priority areas for planning and management to address issues around increasingly dense vegetation. Further, there are opportunities in Goonoo and Pilliga East State Conservation areas to prioritise the development of plans of management that include post-wildfire management strategies.

The plans of management should be informed by the adaptive management framework provided in **Table 13 (page 66)**, and include specific, measurable and spatially explicit management targets.

Adopting finer-scale management units

Current plans of management for the State Conservation Areas (where they exist) treat the entire state conservation area as one management unit. 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 the State Conservation Areas should also contain discrete, finer scale spatial management units nested within the boundaries of the State Conservation Areas. This would enable land managers 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.

This report provides 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 vegetation – to improve ecological outcomes in the Brigalow and Nandewar State Conservation Areas.

Grouping the State Conservation Areas for planning purposes

Many of the 23 Brigalow and Nandewar State Conservation Areas are relatively small in size and are 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 reserve areas and state forests, such as Pilliga, Pilliga East and Pilliga West State Conservation Areas.

The NRC believes the 23 Brigalow and Nandewar 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 of the State Conservation Areas, for example Durridgere and Bingara State Conservation Areas. 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 the State Conservation Areas should be subject to consultation with relevant National Parks and Wildlife Regional Advisory Committees. **Table 15** provides an example of an initial proposal for the consolidation of the State Conservation Areas, reducing the number of plans of management required from 23 to eight.

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 before finalising any groupings.

The order in which plans of management for each group are developed should be based on addressing the priority areas for planning and management identified in **Section 5.7.4**.

Table 15: Proposed Brigalow and Nandewar State Conservation Areas planning groups

Planning group	State conservation area		National Parks and Wildlife Service 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	

7 Exploring alternative funding and cost recovery models

Actively managing cypress forests for environmental values will incur costs associated with interventions like pest and weed control, fire management, track and access management, and ecological thinning (see **Chapter 9** for costs estimates for ecological thinning scenarios). The cost is likely to increase if predictions around an increase in dense vegetation in the future hold true (see **Section 5.6**).

Given the finite resources available to manage public lands, the NSW Government and forest managers should explore alternative funding, cost recovery and cost sharing models for active landscape management to:

- more cost-effectively generate ecological outcomes
- improve long-term sustainability of management programs
- allow for management for ecological objectives over a larger area
- deliver social and economic benefits.

The current regulatory framework for the State Conservation Areas treats economic and environmental values as mutually exclusive. This results in missed opportunities to deliver enhanced ecological outcomes through innovative funding arrangements.

Instead, in areas such as the cypress forests of the Brigalow and Nandewar State Conservation Areas, land managers should aim to find opportunities to achieve more cost-effective environmental outcomes.

Alternative funding and cost recovery models may include:

- cost recovery schemes
- goods for services schemes
- alternative funding sources.

7.1 Cost recovery

Government regulation should be designed to meet its objectives effectively, with minimal cost to the community irrespective of the particular economic, social or environmental objective. One component of the cost to the community is the recovery of regulatory costs (Australian National Audit Office, 2007).

Cost recovery is the recovery of some or all of the costs of a particular activity. Cost recovery charges can fall into two broad categories, either fees for goods and services or taxes such as levies, excises and customs duties (Department of Finance, 2014).

Cost recovery can improve the efficiency with which products and services are produced and consumed (Australian Government, 2005). Charges for goods and services can give an important signal to users or their customers about the cost of resources involved. It may also improve equity by ensuring that those who use government products and services, or who create the need for regulation, bear the costs (Australian Government, 2005).

The NSW Government has a NSW Treasury Policy and Guidelines Paper that provides guidance around service costing, including contracting out service provision and pricing of

goods and services (NSW Treasury, 2007). The Australian Government also has cost recovery guidelines that guide the design, implementation and review of cost recovery activities undertaken by any Australian Government entity (Department of Finance, 2014).

All management interventions in the State Conservation Areas will incur administrative and operational costs for 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.

In a cost recovery scheme for forest management, the land manager will incur the direct costs of program management and on-ground intervention, offsetting these costs by revenue generated from the sale of forest by-product materials that may be produced.

Legal advice indicates that opportunities for cost recovery or other commercial benefits within the State Conservation Areas are permitted, but must be a secondary consideration to the promotion of improved ecological outcomes. This is explored further in **Section 12.1**.

The NRC has investigated the potential costs and cost recovery options associated with ecological thinning in the State Conservation Areas in **Chapter 9**.

7.2 Goods for services schemes

In a goods for services scheme, the land manager incurs the costs of program management, but a third party bears either the full or partial cost of delivering specified ecological outcomes in exchange for access to specified by-product materials. For example, goods in the form of forest products may be traded for services, such as 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, 2009). 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, 2009). Over 1,400 contracts and agreements have been initiated across all States (Pinchot Institute for Conservation, 2014). **Table 16** lists the legislated goals for stewardship contracts in the United States.

Table 16: Legislated[27] 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).

7.3 Alternative funding sources

In light of the increasing pressures on natural resource management funding, land managers may consider alternative funding streams to fund management activities. In the Brigalow and Nandewar region, this may include private sector donations or funds sourced through programs such as Resources for Regions. As Resources for Regions currently focuses on infrastructure constraints, the fund's objectives would need to be expanded to include landscape management objectives.

27 Public Law 108-7.

Part III – Options for an active and adaptive management program

8 Potential management options

8.1 Identifying potential management options

As shown in the state and transition model in **Section 5.7.3** (**Figure 16**), the NRC has identified four potential management intervention options that should be available for managers to use in the State Conservation Areas:

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

Of these proposed active management options, ecological thinning and targeted grazing represent new intervention options for the State Conservation Areas. The NRC has recommended similar options in previous forest assessments. In addition, a range of other management options were also considered, including alternatives suggested by stakeholders during public consultation processes. **Box 1** provides more information on previous advice and additional options considered**.**

In **Table 17**, the NRC has linked the identified interventions to each of the additional management objectives proposed for managing dense vegetation (see **Section 5.7.2**, **Table 12**). In some cases, the additional interventions identified could also support the achievement of other specific management directives within the current plans of management.

Table 17: Interventions linked to additional management objectives for the State Conservation Areas

Additional objectives		Primary interventions	
		Additional	**Existing**
1	Maintain and enhance vegetation stand complexity including promoting areas of sclerophyllous 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 18 provides a brief overview of the four active management options, including their potential ecological benefits and current application.

Table 18: 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 plant and animal 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 and black 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 plant species and providing 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, 2013b).
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, 2012c).

* **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

Any of the proposed interventions 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 cypress pine trees from the landscape and reduce habitat extent or quality for rare and threatened species for many generations (Bowman & Latz, 1993).

To manage these risks, plans of management should identify ecologically appropriate intensity, frequency and/or locations for each intervention option (Verschuyl et al., 2011).

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 8.5**.

In this review, the NRC has assumed that current pest and weed management 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 regime. However, a brief overview of current pest and weed management activities has been included in **Section 8.6**.

Box 1: 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 available on the impact of dingo exclusion or reintroduction on foxes, and consequent outcomes for native animal species. However, there is very little information on 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).

8.2 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 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 (McDonald-Madden et al., 2010; McCarthy & Possingham, 1997).

For example, depending on the area, managers may choose to address Class 2 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 vegetation density and extent over time, particularly following favourable conditions for cypress or bulloak regeneration.

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; Kalies et al., 2010).

For example, ecological thinning could be applied to open up dense stands of 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 cypress 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 19 describes some of the potential combinations and sequences for active management options, including potential ecological risks.

Table 19: 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 cypress pine or bulloak (after first and second intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Damage to mature cypress pine or bulloak 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 cypress pine or bulloak after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature cypress pine or bulloak 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** ** event, not intervention*	*Prescribed fire*	▪ Complete removal of cypress pine or bulloak (after first and second intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Damage to mature cypress pine or bulloak 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 cypress pine or bulloak after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature cypress pine or bulloak trees (second intervention)

Proposed additional objective	First intervention	Second intervention	Potential ecological risks
	Prescribed fire	*Prescribed fire*	▪ Complete removal of cypress pine or bulloak (after first and second intervention) ▪ Decrease coarse woody debris (after second intervention) ▪ Damage to mature cypress pine or bulloak 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 cypress pine or bulloak after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature cypress pine or bulloak 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 cypress pine or bulloak after second intervention) ▪ Inappropriate disturbance with machinery (after first intervention) ▪ Damage to mature cypress pine or bulloak trees (second intervention)

8.3 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). For example, 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.*" (NSW Government, 2014b)

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 cypress pine trees).

In either case, thinning residues may be left in the forests, or removed. **Figure 19** shows an example of ecological thinning with residues left on the ground.

Figure 19: Example of thinning around a habitat tree with residues left on the ground

In all cases, some dense stands of 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 were identified in **Table 17** and include:

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

8.3.1 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 20** outlines the potential benefits of ecological thinning.

Table 20: Benefits of 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; Carey, 2003; Sullivan et al., 2001; De La Montana et al., 2006; Peacock, 2008). ▪ Ecological thinning provides opportunities to incorporate vegetation mosaics or patchiness into the landscape (Archibald et al., 2010; McComb et al., 1993). 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; Shelly, 1998; Finkral & Evans, 2008). ▪ Ecological thinning can promote a positive response in plant species diversity, including in herbaceous vegetation (Moore et al., 2006; Halpern & Spies, 1995; Schoonmaker & McKee, 1988; Sullivan et al., 2001; Bauhus et al., 2001)
Increase eucalypts in cypress pine-dominated landscapes	▪ Ecological thinning can increase eucalypts in the cypress pine-dominated landscape by promoting tree growth in existing eucalypts, and increasing recruitment over time (Maher, 1995). ▪ **Section 5.4.1** explained the ecological value of eucalypt species within the landscape. ▪ Ecological thinning of dense cypress pine regeneration can promote recruitment of young eucalypts within the gaps created. Ecological thinning of cypress pine trees competing with eucalypts with high habitat potential will reduce stress and promote the growth of existing trees (see **Figure 19**).
Promote tree growth and habitat quality	▪ Ecological thinning can promote growth in remaining trees to enhance habitat values, including eucalypts and cypress pine (Horne & Robinson, 1987; Sullivan et al., 2001). Ecological thinning can also encourage regeneration of species in both healthy and declining stands (Archibald et al., 2010). ▪ 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; Shelly, 1998). 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.).
Increase viability of fauna, including threatened species	▪ Improving, or increasing, particular habitat types through ecological thinning is likely to support or increase the viability of fauna (De La Montana et al., 2006; Verschuyl et al., 2011; Kalies et al., 2010; Carey & Johnson, 1995; Hansen et al., 1993; Ruggiero et al., 1991). ▪ Date et al. (2000) indicates that within 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)

Benefit	Discussion
Increase coarse woody debris by leaving a proportion of thinning residues in place	▪ Coarse woody debris provides important habitat for small ground dwelling mammals, reptiles and their prey (Lunney et al., 1991). ▪ 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 the 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 the mature white cypress pines referred to as 'old greys' – see **Figure 20**) 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 (Archibald et al., 2010). ▪ In general, large canopy trees tend to suffer stress and mortality in the presence of dense cypress pine regeneration, particularly during water scarcity, and more cypress pine regeneration is likely to replace dying 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 above-ground plant biomass (Central West Catchment Management Authority and Western Catchment Management Authority, 2010), which can reduce erosion (such as sheet and rill erosion) and improve overall soil health (for example, carbon content and structure) and soil biodiversity (NSW Office of Environment and Heritage, 2006).
Increase stock of carbon stores	▪ Growing trees sequester carbon from the atmosphere, steadily increasing the carbon stock until they mature and growth is balanced by decay (Powers et al., 2012). ▪ Thinning can stimulate growth in existing and new trees (Horne & Robinson, 1987; Dwyer et al., 2010), which can sequester carbon more rapidly than undisturbed forest sites (Dore et al., 2012; Dwyer et al., 2010). ▪ Structurally diverse woodlands dominated by white cypress pine are effective sinks for carbon (Eldridge & Wilson, 2002). Dense stands of small 'whipstick' white and black cypress pine store the same amount of carbon as scattered woodland trees and about half that of a dense woodland (Eldridge & Wilson, 2002). ▪ Black cypress pine has moderate potential to sequester atmospheric carbon (Greening Australia & CSIRO, 2014b) ▪ Bulloak has a moderate to high potential to sequester atmospheric carbon (Greening Australia & CSIRO, 2014a) ▪ In carbon terms, active management introduces an important trade-off between carbon stock size (standing biomass of trees) and the carbon stock stability.

Figure 20: Example of a mature white cypress pine with spreading crown (sometimes referred to as 'old greys')

8.3.2 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 21 outlines the potential risks associated with ecological thinning, expanding on the high-level risks presented in **Table 19**.

Table 21: Risks associated with ecological thinning

Risk	Discussion
Reducing coarse woody debris if thinning residues are removed below a minimum level	▪ In general, management practices that deplete 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 in cypress pine forests. As such, there are currently no known specific threshold levels for coarse woody debris in cypress pine reserves. ▪ In some areas, coarse woody debris levels may need to be increased where little-to-no woody debris exists (for example, in existing dense stands of cypress pine).
Reducing nutrients and litter if thinning residues are removed below a minimum level	▪ 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 soil water-holding capacity and help promote germination and growth of groundcover species.
Reducing stocks of carbon if thinning is removed and burnt	▪ White cypress pine forests can contain significant stocks of carbon in biomass (for example, trunks, branches and foliage), dead organic matter and soil (McHenry et al., 2006). ▪ Disturbance events can reverse sequestration, especially through planned and unplanned fires (Sorensen et al., 2011) . Thinning and biomass removal are also disturbance events and, as such, can result in the release carbon to the atmosphere (Finkral & Evans, 2008). ▪ Even though thinned stands will usually sequester carbon as the remaining trees grow, the overall carbon balance may result in net emissions.
Increasing fire fuel loads if thinning residues are left *in situ*	▪ 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 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 cypress pine	▪ This risk can be managed by appropriate prescriptions such as retaining large 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 impacted 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 koalas because they provide vigorous growing eucalyptus foliage and higher moisture content in the foliage (Kavanagh & Barrott, 2001).

Risk	Discussion
Machinery impacting and/or disturbing soil, soil crusts, vegetation and fauna	▪ 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, pests, feral predators and native species invasion	▪ This risk can be managed by appropriate pest and weed management strategies. ▪ Key pests and weeds found in the 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, 2012c). ▪ 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).

8.3.3 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 'ecological non-commercial thinning' of dense cypress pine regrowth to enhance habitat values and ecosystem function.[28]

Thinning to maintain and improve environmental outcomes in NSW

White cypress pine and black cypress pine are defined as invasive native species under certain elements of the NSW native vegetation regulations. Invasive native species are defined as:

> *"Species [which are] densely regenerating or is invading plant communities in which the species does not generally occur, which is causing the decline in the structure or composition of the vegetation community."*(NSW Government, 2014a)

As a result, white and black cypress pine can be cleared or thinned as invasive native species on private and leasehold land to promote a mosaic of vegetation structure and species (NSW Government, 2014a, 2014b). Under the rules and tests of the regulations, this activity is deemed

[28] 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 ecological thinning and non-commercial thinning should be implemented on public lands as good natural resource management practice (Natural Resources Commission, 2010b).

to maintain and improve environmental outcomes. Vegetation mosaics provide the necessary habitat to support native flora and fauna and ecological processes (Cameron, 2003; Carey, 2003; Hobbs, 1999; De La Montana et al., 2006; Sullivan et al., 2001).

Table 22 sets out some of the proposed prescriptions that apply to clearing or thinning white cypress pine and black cypress pine under the native vegetation regulations to maintain and improve environmental outcomes.

Table 22: Prescriptions to manage white and black cypress pine under NSW native vegetation regulations

	Clearing or thinning cypress as an invasive native species	Thinning cypress as a species within a vegetation formation
Prerequisite	▪ Must be listed as an invasive native species under Ministerial Order - white and black cypress pine are listed state-wide as invasive native species	▪ Must be a native species that forms part of a vegetation formation listed under Ministerial Order - Dry sclerophyll forests (shrubby formation) are listed within the assessment area for this review - White and black cypress pine are found in dry sclerophyll forests
Management activity	▪ Burning ▪ Clearing individual trees with nil to minimal disturbance to soil and groundcover ▪ Clearing plants at paddock scale with nil-to-minimal disturbance to soil and groundcover in the short or long term	▪ Thinning individual trees with minimal disturbance to soil, groundcover and non-target plant
Area	▪ Between 20-80 percent of a landholding, depending on the management activity applied	▪ Up to 1,000 hectares per landholding for central NSW ▪ Patches greater than 1 hectare in size but not further than 100 metres from an adjoining patch
Size	▪ White and black cypress pine with stems up to 30 centimetres diameter breast height over bark	▪ Trees greater than 1.3 metres in height ▪ Trees with stems up to 25 centimetres diameter breast height over bark
Nominated stem densities and spacing	▪ Greater than or equal to 20 white and/or black cypress pine stems per hectare (under 30 centimetres diameter breast height over bark) when clearing individual trees	▪ Greater than or equal to 200 stems per hectare ▪ 7 metres spacing between trees

Ecological thinning in NSW river red gum reserves

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).

International examples

Large-scale thinning programs to restore habitat for flora and fauna have been in use for a long period in North American production forests (Manning et al., 2012; Noss et al., 2006; Carey, 1991). Many studies have documented the ecosystem response of thinning (Carey, 2003, 1991, 2000; Carey & Johnson, 1995; Wilson & Puettmann, 2007; Olson et al., 2014). Overall, studies by Kalies et al. (2010) and Verschuyl et al. (2011) suggest thinning programs have had a neutral or positive impact on environmental values.

Carey (2003) also confirmed the findings of various authors that actively managing dense regeneration in temperate, boreal and tropical forests maintained and enhanced biodiversity values.

Other international research includes:

- Wilson & Puettmann's (2007) review of large-scale thinning experiments in the Pacific north-west of the United States of America, which found that thinning prescriptions increase variability in forest stands and enhanced habitat quality beyond that provided by stand-level prescriptions
- Covington et al. (1997), which found that thinning improved moisture availability and native plant diversity in a fire-affected regrowth stand of Ponderosa Pine in the south-west of the United States of America
- Broome et al. (2014), which found that thinning improved the habitat for Capercaillie (*Tetrao urogallus*) in Scots pine (*Pinus sylvestris)* forests in the United Kingdom.

8.3.4 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 objectives
- structure of the surrounding vegetation (not just the size and age of trees).

Section 5.5 described the spatial extent and distribution of denser vegetation. Larger areas of denser vegetation should be considered priority areas most likely to benefit from ecological thinning, including those patches greater than 500 hectares found in Pilliga, Pilliga West and Trinkey State Conservation Areas (**Section 5.7.4**).

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 cypress pine may be relatively rare in the surrounding landscape (and other tenures) and may need to be retained in the State Conservation Areas to support landscape heterogeneity.

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 when undertaking ecological thinning in the State Conservation Areas. These principles are set out in **Table 23**, and promote the maintenance and improvement of structural and floristic diversity across the State Conservation Areas.

Table 23: Principles for ecological thinning in the Brigalow and Nandewar 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 by 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 broader landscape
5	Promote areas of sclerophyllous mid-storey and shrubs without losing all existing mid-storey and shrubs habitat through the activity
6	Maintain or enhance levels of coarse woody debris where necessary, practical and consistent with other objectives, such as objectives for fire management
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
10	Be undertaken under the authority of the NSW National Parks and Wildlife Service in accordance with the Adaptive Management Plan for the Brigalow and Nandewar State Conservation Areas and the relevant plan of management.

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.

In practice, managers may choose to identify a suite of discrete thinning and/or gapping levels to allow for a 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.

Extending this approach, and in consultation with agency stakeholders, the NRC has developed a possible framework for ecological thinning treatment levels, as shown in **Table 24**. Managers could also look to prescriptions applied to thinning white and black cypress pine on private land that meet threshold rules to maintain and improve environmental outcomes (**Table 22**).

Table 24: Framework for ecological thinning and potential treatment levels

Type of ecological thinning		Potential treatment levels		
		Treatment 1	**Treatment 2**	**Treatment 3**
1	**Thinning vegetation regrowth to a uniform, predetermined level**	1,000 stems per hectare (3 metre tree spacing)	300 stems per hectare (6 metre tree spacing)	150 stems per hectare (8 metre tree spacing)
2	**Thinning trees to open up dense stands (in some cases around specified features such as habitat trees)**	10 metres squared basal area per hectare	8 metres squared basal area per hectare	6 metres squared basal area per hectare
	Comment	▪ Promotes successful seed germination and abundant grasses (Lacey, 1972) ▪ Promotes understory growth and a positive biodiversity response (Cameron, 2003)		▪ Trending towards pre-European density levels (Lunt et al., 2006) ▪ Higher than nominated stem densities for dry sclerophyll forest (200 per hectare) and white/black cypress pine (20 per hectare) (NSW Government, 2014b, 2014a)

8.4 Targeted grazing

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

8.4.1 Discussion of potential environmental benefits and risks

In the past, heavy livestock grazing caused substantial damage across Australian ecosystems, including cypress pine forests and associated woodlands (Lunt et al., 2007). Total grazing pressure from pest species (such as rabbits) and native herbivores (such as 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 increase in the number of noisy miners (*Manorina melanocephala*) (Bowen et al., 2009).

Despite the widespread historical impacts of livestock grazing, in some specific circumstances 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 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)
- targeted livestock grazing provides a disturbance regime to maintain and enhance vegetation structure and composition (NSW Office of Environment and Heritage, 2012a)
- periodic livestock grazing can 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).

Further, grazing will not promote improved 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 monitoring and data on grazing impacts in cypress forests has meant that it is not possible to assess how livestock grazing affects conservation values or fire risk in these areas.

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, 2013b). 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, 2013b).

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.

8.4.2 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)[29]
- 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, 2013b).

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

8.4.3 Where and how these interventions could be applied

Targeted grazing should only be applied to areas where management objectives can be reasonably predicted, and 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 secondary activity following ecological thinning, to maintain vegetation structure and diversity, or
- 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.

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 cypress forests as an active management tool for ecological outcomes.

Ideally, differential areas of fire risk could be identified within the 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, 2012c).

8.4.4 Lessons from previous grazing strategies

Previous grazing strategies in cypress 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 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 fire danger is significantly reduced at these levels (Wilson et al., 1997).

8.5 Improved use of prescribed fire for ecological outcomes

Fire is a natural feature of many environments and is essential for the survival of some plant communities (Prober et al., 2008). Prescribed fire has been described as the 'process of planning and applying fire to a predetermined area, under specific environmental conditions, to achieve a desired outcomes'(Western Australia Parks and Wildlife, 2014).

Prescribed 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).

Cultural burning is a practice used by Aboriginal people to 'enhance the health of land and its people'(Firesticks, 2014). It can be used to promote suitable habitat for native plants and animals, reduce fuel loads and increase access and amenity for people (Firesticks, 2014). During consultation for this review, Aboriginal stakeholders indicated the cultural knowledge of Aboriginal burning practice has been lost in the Brigalow and Nandewar region.

Zimmer et al. (2012) suggest mixed *Eucalyptus-Callitris* stands, that contain high basal area of *Callitris* species, can reduce fire intensity. The authors further suggest protecting *Callitris* species populations over the longer term may reduce forest flammability and potential fire intensity.

Studies focusing on black cypress pine indicate long intervals between fires favour dominance by black cypress pine. However, two fires in quick succession can cause local extinction of black cypress pine, especially in mixed stands where eucalypts can grow faster and dominate the stand (Zimmer et al., 2012).

However, other studies have shown that wildfire severity can be altered as a function of forest fuels and stand structure manipulations (Hurteau et al., 2011). Planned and unplanned fires can alter carbon stock in forest ecosystems (Sorensen et al., 2011).

Prescribed fire is already used within the State Conservation Areas to address both ecological function and asset protection. There are 22 fire management strategies for Brigalow and Nandewar State Conservation Areas (see **Attachment 2** for list).

The fire management strategies 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, 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 timing for 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 decision management 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 the State Conservation Areas 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 21**)[30]
- wildfires have burnt up to 40,000 hectares (or 20 percent) of the State Conservation Areas since 2005 (**Figure 21**) – these fires can remove entire stands of vegetation, including both fire-tolerant (eucalypt) and fire-intolerant (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 through 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.

30 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 8.2**).

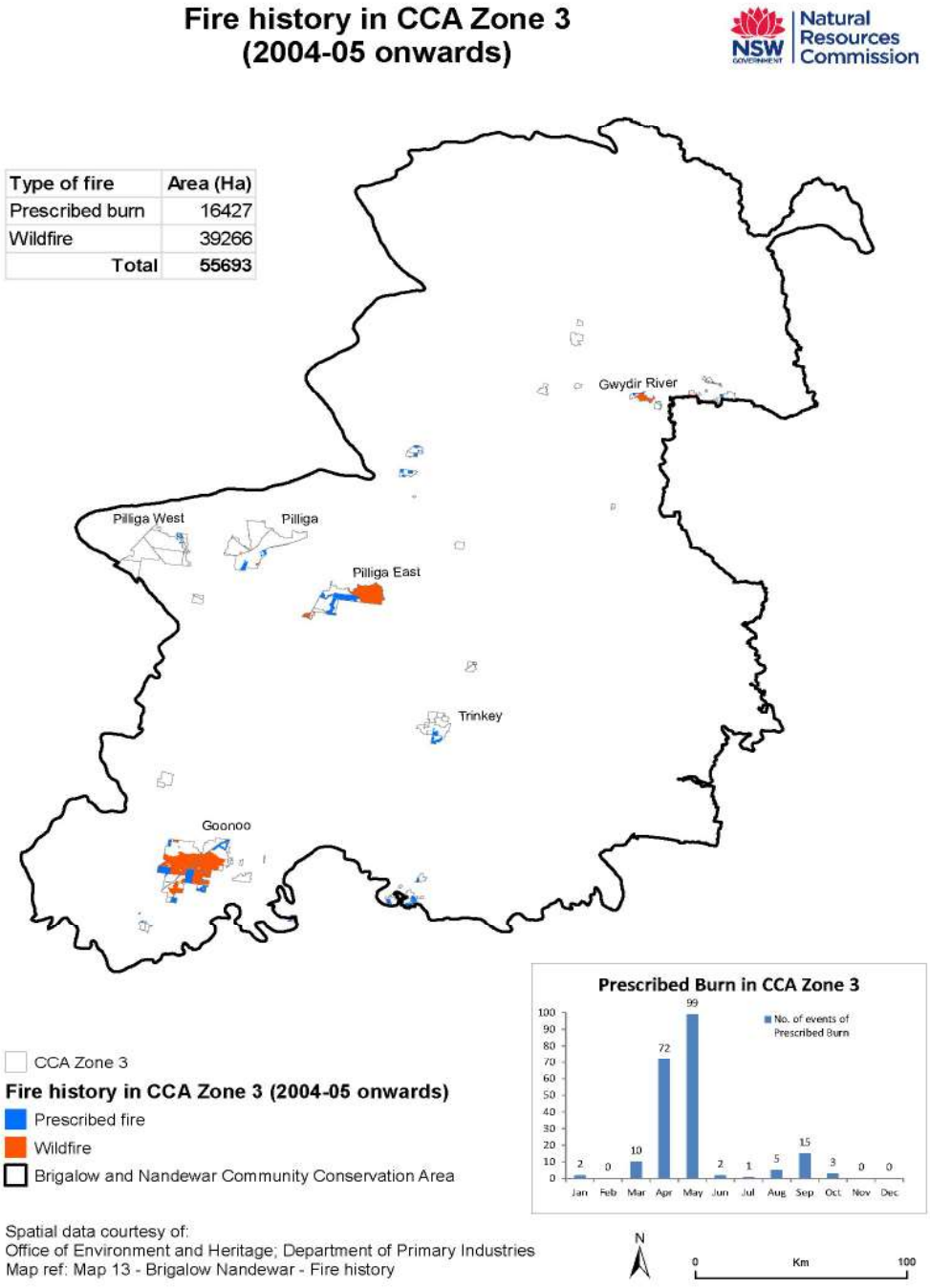


Figure 21: Fire history in the Brigalow and Nandewar State Conservation Areas since 2004-2005

8.6 Pest and weed management

Over 1,650 weeds have established in NSW. Many pest animals, such as rabbits and feral goats, are well established and cannot be eradicated by present methods. Species such as foxes and cats are also found state-wide (NSW Environment Protection Authority, 2012). The number of new invasive species entering NSW is largely unknown (NSW Environment Protection Authority, 2012).

Pest animals and weeds impact the environment, the economy and society. For example, some estimates include:

- over 70 per cent of all listed threatened species in NSW are impacted by weeds and pest animals (NSW Environment Protection Authority, 2012)
- weeds have a direct economic impact of nearly $2 billion each year in NSW (Kalisch Gordon, 2014)
- over $740 million annually of direct economic impacts by vertebrate pests on the agricultural industry across Australia (Gong et al., 2009)

The broader impacts on ecosystem health are likely to be significant, but are largely unassessed (NSW Environment Protection Authority, 2012).

The *NSW Invasive Species Plan 2008-2015* and the *NSW Biosecurity Strategy 2013-2021* set out the NSW Government's strategy to manage the new, emerging and widespread weeds in NSW (NSW Department of Primary Industries, 2008; NSW Government, 2013a). More specifically, the NSW Government has committed to reduce the impact of invasive species at priority sites in NSW reserves (NSW Government, 2011).

The NSW National Parks and Wildlife Service's regional pest animal and weed management strategies aim to minimise the impact of invasive species on biodiversity, protected areas and the community in NSW reserves (see for example, NSW Office of Environment and Heritage, 2012b). The Northern Plains, Northern Tablelands and Blue Mountains pest animal and weed strategies govern pest and animal management in the Brigalow and Nandewar State Conservation Areas (NSW Office of Environment and Heritage, 2012c, 2012d, 2012b).

The NSW Government is also undertaking a supplementary pest control trial in partnership with volunteer shooters to complement National Parks and Wildlife Service's regional pest animal and weed management strategies (NSW Office of Environment and Heritage, 2014e). The National Parks and Wildlife Service has selected 12 reserves for the trial including Goonoo State Conservation Area, aiming to reduce fox and goat populations. The NRC will independently evaluate the trial and provide advice to the Government on the future of the program in 2016 (Natural Resources Commission, 2014).

Attachment 18 shows the management priorities for pest animals and weeds in each of the State Conservation Areas. Only Goonoowigal and Tingha Plateau State Conservation Areas have been identified with vegetation communities containing cypress species that are considered at risk by pest animals and weeds. Some of the priority pests and weeds for management include:

- coolatai grass (*Hyparrhenia hirta),* tiger pear (*Opuntia aurantiaca*), african boxthorn (*Lycium ferocissimum)* and mother-of-millions *(Bryophyllum delagoense)*
- wild dogs (*Canis familiaris*), foxes (*Vulpes vulpes*), feral goat (*Capra hircus*), feral pigs (*Sus scrofa*) and rabbits (*Oryctolagus cuniculus).*

9 Potential management costs

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, this chapter provides a high-level indication of potential costs and cost recovery options that may be associated with active and adaptive management, particularly ecological thinning.

9.1 Overview of modelled ecological thinning program

The NRC has estimated the potential costs associated with ecological thinning in the State Conservation Areas by modelling an indicative ecological thinning program.

The NRC modelled a five year ecological thinning program in areas of the Pilliga, Pilliga West and Trinkey State Conservation Areas with denser canopy cover (Classes 3 and 4). The NRC has provided lower and upper cost and cost recovery estimates for this program by varying the modelled thinning density. The variables, assumptions and rationales underpinning the NRC's modelled program are outlined in **Table 26** (see over page).

As discussed in **Chapter 0**, the NRC recommends that the NSW Government seeks to recover at least part of the costs of undertaking active and adaptive management. As a result, the NRC assessed costs for three cost recovery options:

1 no cost recovery

2 partial cost recovery

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

The modelled program involves treatment of approximately 15,525 hectares of vegetation, once exclusions for patch size, sensitive areas and recent wildfire events are applied to the 20,121 hectares of denser canopy cover (Classes 3 and 4) within the target state conservation areas. **Table 25** sets out **t**he total area treated, and area treated per year. Under the modelled program, around one and a half percent of all the State Conservation Areas may be subject to ecological thinning in any year, and up to 8 percent in total over the five year program.

Table 25: Potential program of ecological thinning

	Class 3 (21-30 percent cypress canopy density)	Class 4 (greater than 30 percent cypress canopy density)	Total
Total area (hectares)	9,873	5,652	15,525
Approximate area treated per year over a five year program (hectares per year)	1,975	1,130	3,105

The NRC developed this model program to provide a practical means to estimate the potential costs of ecological thinning on a year-by-year basis. A full breakdown of the NRC's cost estimates are presented towards the end of this chapter in **Table 29**. In practice costs may vary, as ecological thinning could continue over a longer time period or over a larger or smaller area depending on the desired ecological objectives.

Table 26: Modelled ecological thinning program assumptions and rationale

Variable	Modelled program	Assumptions and rationale
Duration	Five year planning and implementation program	▪ 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 as part of the NSW Government's Brigalow Initiative.
Treatment area	All patches of denser vegetation (Class 3 and 4) in Pilliga, Pilliga West and Trinkey State Conservation Areas	▪ These state conservation areas were identified as priorities for planning and management in Section 5.7.4. ▪ Large areas of denser vegetation are likely to have an adverse impact on ecological outcomes.
Exclusions from calculation of treatment area	Patches less than one hectare in size	▪ Ensures some dense patches of vegetation remain within a mosaic of different vegetation types to support ecological function. ▪ 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). ▪ 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 line with conditions in the NSW Government's draft Ministerial Orders for thinning native vegetation on private land (NSW Government, 2014b). This assumption should be tested as part of the adaptive management process.
	Ecologically and culturally sensitive areas	▪ If any active management interventions occur in the State Conservation Areas, sensitive areas near ecological, environmental and cultural attributes (see **Attachment 3**) would need to be either excluded from management, or potential risks would need to be closely managed. ▪ The NRC has excluded these areas from calculations of treatment area that inform cost estimates for the modelled program.
	Areas that have expereinced recent wildfire events	▪ Stands of dense vegetation in areas that have experienced recent wildfire events are likely to have been damaged by fire and are unlikely to require ecological thinning. ▪ Areas with recent wildfire events should have a post-fire management strategy in place.

Variable	Modelled program	Assumptions and rationale
Thinning intensity	Two modelled intensities: ▪ **Moderate thinning** – removal of 8 to 15 percent of standing volume ▪ **Heavy thinning** – removal of 20 to 35 percent of standing volume.	▪ These thresholds were selected given the ecological focus of thinning and estimated standing stem densities and volumes within five of the State Conservation Areas based on an analysis of LiDAR and ADS40 data. ▪ Moderate thinning aims to promote the regeneration of groundcover, shrubs and tree species such as eucalypts, while also retaining and promoting the growth of cypress pine trees. ▪ Heavy thinning option involves a greater reduction of cypress pine to provide more potential to increase regeneration of groundcover, shrubs and other tree species. ▪ These thinning thresholds were chosen for modelling purposes only, and were not intended to be used as default thinning prescriptions for plans of management. In practice, it is likely that the plans of management will specify varied thinning regimes to achieve a range of environmental objectives; these thresholds could be greater or less than the modelled thinning thresholds.
Cost recovery options	**Option 1 – No cost recovery**	▪ National Parks and Wildlife Service undertakes ecological thinning and retains residues on-site, and incurs all costs of the activity.
	Option 2 – Partial cost recovery	▪ National Parks and Wildlife Service undertakes ecological thinning and removal of residues, and sells residues to the market place. National Parks and Wildlife Service receives current equivalent market price for residues.
	Option 3 – Goods for services scheme	▪ National Parks and Wildlife Service engages a contractor to undertake ecological thinning, including removing residues. National Parks and Wildlife Service incurs project management costs. The contractor bears the risk of seeking cost recovery of activity through selling residues in the market place.
Thinning method	Machine thinning	▪ It is assumed thinning would be conducted using machinery that could be adjusted to accommodate the size of trees being thinned, particularly where smaller stems are the focus of thinning activities. ▪ Machines provide an efficient and safe working environment for operators. ▪ Facilitating an investment in machinery reconfiguration would require a commitment to a program over a reasonable time period.
Revenue from sale of residues	Current equivalent state forest mill door price for white cypress pine sawlogs (production volume)	▪ Modelling assumes current equivalent mill door price for white cypress pine sawlogs (production volume) from state forest white cypress pine sawlog supplies. ▪ Price supplied in-confidence to the NRC by Forestry Corporation of NSW. ▪ Non-production volumes are not expected to generate revenue at this stage, and have not contributed to modelled revenue estimates.

9.2 Estimating costs for Option 1 – ecological thinning, no cost recovery

The NRC estimated the costs associated with the modelled ecological thinning program if no cost recovery mechanisms are put in place. This analysis was based on estimates of program management costs, and direct thinning costs, and is indicative of the modelled program only. In practice, the total program costs would increase or decrease in line with increases or reductions in the total area being actively managed.

9.2.1 Estimating program management costs

A breakdown of management costs associated with the indicative ecological thinning program, including key assumptions underpinning the cost estimates, are shown in **Table 27**.

Active and adaptive management within the 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.

Table 27: 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 15,525 hectares over five 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.
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 approximately 14 percent over a direct supervision approach.	Audits completed by agency staff with audit experience.
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 15,525 hectares over five years), 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 costs, including LiDAR and ADS40 data costs. These costs have also been benchmarked against data from similar land management activities from other jurisdictions.

The indicative costs are based on the adoption of an outcomes-based performance audit model for accountability. 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. An accountability model that uses periodic audits reduces overall program costs compared with full-time onsite supervision models.

If a direct supervision model is adopted instead of an outcomes based performance audit model, the NRC estimates that the cost of the modelled ecological thinning program would increase by up to 15 percent. This is based on the assumption that the program would require 1-2 full-time equivalent employees (with relevant experience) who would be responsible for on-going supervision of contractors undertaking the thinning operations.[31]

Program management costs are expected to decrease over time as active and adaptive management processes become standard practice within NSW reserves and after any initial set-up costs have been incurred.

9.2.2 Estimating 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 $150 per hectare (for moderate levels of thinning) to $335 per hectare (for heavy levels of thinning) depending on the thinning intensity and density of the vegetation being treated. 10 to 20 percent of direct thinning costs are assumed to involve transportation of production volume to processing centres.

The NRC considered various harvesting configurations and machine types to derive cost estimates for ecological thinning activities; in particular, harvesting configurations and machinery that are already in use within the region, and those suitable for small tree operations.[32] The machine rate varies by stem density, thinning intensity, and the expected distribution of stem size. The cost estimates also took into account the potential scale of operations, area treated and staffing requirements to implement different scenarios.

Manual alternatives to machine thinning were not costed, but are discussed further in **Box 2**.

There may be opportunities to align ecological thinning activities within the 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.

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

32 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 harvesting machines (for example, Komatsu) with specialised felling heads such as Waratahs.

Box 2: Potential for applying manual thinning techniques

The NRC's cost estimates are based on the use of mechanical thinning. Manual thinning techniques are an alternative management option for thinning smaller stems. In addition, manual thinning is sometimes required as a follow-up intervention to particular types of mechanical thinning; for example, chopper roller techniques.

Manual thinning has less short-term ecological impact than mechanical thinning, and is useful for thinning in areas that are difficult to access.

However, it is significantly more expensive and time consuming than mechanical methods, and would substantially increase the overall program costs if implemented. It can also present greater risks in terms of work safety.

While manual thinning is likely to result in greater employment benefits in the regions where ecological thinning is being carried out, the long-term sustainability of such programs is not certain given the high costs. Employment is likely to be casual and would cease on completion or suspension of the program.

Although the NRC has not included manual thinning within the modelled ecological thinning program, State Conservation Area managers should have the flexibility to apply manual thinning within plans of management where appropriate.

9.3 Estimating costs for Option 2 – partial cost recovery

Under a cost recovery 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.[33]

The NRC investigated commercial opportunities for cypress thinning residues. Currently, markets for ecological thinnings are limited to large white cypress pine sawlogs (referred to as production volumes) and smaller white cypress pine and black cypress pine stems that can 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. More information about these commercial opportunities can be found in **Attachment 19**.

9.3.1 Cost recovery from production volumes

The NRC has analysed ADS40 and LiDAR[34] data to estimate the potential available annual timber volumes that might arise from the modelled ecological thinning program, the results of which are presented in **Table 28**.[35] These volume estimates are indicative only, and actual volumes arising could vary markedly both within and between years in a program.

The estimates are based on LiDAR analysis of stems per hectare for differing tree heights (greater than 12 metres, 3-12 metres, and less than 3 metres tall).

33 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.

34 This analysis collected data specifically for white cypress pine trees in the relevant State Conservation Areas considered in this modelled program (see **Attachment 3** for more information about the spatial analysis).

35 White cypress pine trees found in potential environmentally and culturally sensitive areas have been excluded from estimated gross volumes.

This data allowed for calculation of estimated production and non-production volumes per hectare, where:

- **production volume** refers to trees of a dimension equivalent to or larger than current industry sawlog specifications (generally equivalent to trees over 12 metres tall)
- **non-production volume** refers to trees greater than 3 metres tall but smaller than the current sawlog specifications (generally equivalent to trees less than 12 metres tall).

Table 28: Potential available annual production and non-production volumes

Volume (cubic metres per year - rounded)	Class 3 (21-30 percent cypress canopy density)		Class 4 (greater than 30 percent cypress canopy density)		Total	
Thinning intensity	**Moderate**	**Heavy**	**Moderate**	**Heavy**	**Moderate**	**Heavy**
Production volume	1,825	4,650	1,150	2,950	2,975	7,600
Non-production volume	3,000	7,600	2,000	5,100	5,000	12,700

These volumes assume mechanical thinning with some level of residues retained on the ground to maintain coarse woody debris levels in thinned areas. The preferred level for ecological purposes in these forest types is unknown, and should be determined under an active and adaptive management program.

The potential revenue generated from the estimated production volumes is outlined in **Table 29 (page 110).** These calculations are based on the price of sawlogs sourced from state forests.

9.3.2 Cost recovery from non-production volumes

Cost recovery estimates for non-production volumes from white and black cypress pine arising from ecological thinning in the State Conservation Areas are less certain due to the lack of an established market at present for these residues. As a result revenue from non-production volumes has not been included in the modelled cost estimates.

For example, 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. However, the potential for this firm to pay the costs incurred in extracting and delivering non-production grade ecological thinning residues from the State Conservation Areas is not tested.

A promising future cost recovery opportunity for the use of non-production material generated by ecological thinnings is electricity generation. While there are stakeholder concerns about the carbon emissions of this form of energy generation, whole-of-life-cycle studies have shown that use of woody biomass for energy generation can result in net carbon benefits after accounting

for the benefits of fossil fuel displacement (Ximenes et al., 2012). However, while markets are developing for the use of biomass as fuel, commercial opportunities are limited at present.

The ability to pursue this cost recovery 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 12.4**). 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 unlikely to be feasible given the transport costs involved.

Cost recovery from non-production volumes may be improved by combining an ecological thinning program in the State Conservation Areas with a similar program in state forests. In addition to sharing costs and capitalising on economies of scale, a larger supply may also open up additional avenues for commercial use of the non-production thinning volumes.

See **Attachment 19** for further discussion of commercial opportunities associated with from non-production volumes.

9.4 Estimating costs for Option 3 – goods for services scheme

Section 7.2 explained the use of goods for services schemes in forest management.

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 $46 per hectare (lower range), assuming full cost recovery where the land manager incurs the full cost of program management and all direct costs and benefits are incurred and accrued by the party undertaking the services
- up to $240 per hectare (upper range), assuming partial cost recovery, where the land manager incurs the full cost of program management and partial costs for undertaking the activity.

The estimates provided 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 that this option would need to provide sufficient commercial incentive for a third party to enter into a goods for services contract, particularly one in which they incur all direct costs of the interventions. For example, whether the contracted activity was commercially attractive would depend on the amount of larger trees (production volume) that were likely to be generated as ecological thinning residues under a given management regime. This would depend on the total size, and forest structure and composition of the area being managed, as well as the specified thinning intensity.

9.5 Summary of estimated costs for modelled ecological thinning program

Table 29 summarises the NRC's modelled estimated costs and cost recovery options.

Overall, the NRC estimates that the modelled ecological thinning program with no cost recovery would cost in the vicinity of $3.85-7.1 million over five years, depending on thinning intensity. Although annual costs are likely to fluctuate, on average the program may cost $0.77-1.42 million per annum over five years.

By seeking cost recovery or cost sharing, the NRC estimates that, depending on thinning intensity, costs for the modelled program could be reduced by up to 45 to 65 percent under a cost recovery scheme. Cost recovery would be varied under a goods for services scheme, depending on the amount of goods removed by the contractor after the service has been provided. For example, in some situations the land manager would only incur project management costs.

It is important to note that the estimates are based on a modelled program with nominal variable inputs, and only provide a high-level indication of costs. 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.

Finally, the extent to which cost recovery is feasible depends on the amount of residues with commercial value generated.

Table 29: Summary of estimated costs for ecological thinning program

Option		Total cost for five year program	
		Lower (moderate thinning)	**Upper (heavy thinning)**
Modelled ecological thinning program overview	**Area treated**	15,525 hectares	
	Production volume	14,875 cubic metres	38,000 cubic metres
	Non-production volume	25,000 cubic metres	63,000 cubic metres
Option 1: No cost recovery National Parks and Wildlife Service undertakes ecological thinning and retains residues on-site, and incurs all costs of the activity.	**Program management costs**[36]	$0.95 million	
	Direct thinning costs	$2.9 million	$6.15 million
	Overall program costs (no cost recovery)	$3.85 million	$7.1 million
Option 2: Partial cost recovery National Parks and Wildlife Service undertakes ecological thinning and removal of residues, and sells residues to the market place. National Parks and Wildlife Service receives current equivalent market price for residues.	**Overall program costs**	$3.85 million	$7.1 million
	Cost recovery estimates (revenue)	$1.8 million	$4.55 million
	Nett program costs with partial cost recovery	$2 million	$2.5 million
	Proportion of costs recovered	45 percent	65 percent
Option 3: Goods for services scheme National Parks and Wildlife Service engages a contractor to undertake ecological thinning, including removing residues. National Parks and Wildlife Service incurs project management costs. The contractor bears the risk of seeking cost recovery of activity through selling residues in the market place.	**Overall program costs**	$3.85 million	$7.1 million
	Cost recovery estimates (revenue)	Traded goods	
	Nett program costs with a goods for service scheme	$0.95-$2.5 million	

[36] Annualised equivalent for planning and monitoring and operations management.

9.6 Costs and cost recovery for other active interventions

9.6.1 Targeted grazing

To implement targeted grazing within the State Conservation Areas 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 also 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 adaptive 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.

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 cost recovery from this activity.

9.6.2 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 cypress pine regrowth and maintain the desired state.

The NRC could not obtain accurate figures for prescribed burning currently undertaken in the State Conservation Areas. Typical costs would include equipment and staff time.

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 burning occurred, the objectives of the fire regime, the available methods, and the risk management procedures.

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 about 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, providing the forest types are relatively simple and have predictable drying patterns.

There are no cost recovery opportunities directly associated with prescribed fire interventions.

10 Social and economic impacts, benefits and opportunities

10.1 How social change can affect communities

The magnitude and type of social change in the Brigalow and Nandewar region resulting from active and adaptive management depends on where management activities occur and their likely nature, extent and duration. As such, the NRC's recommendations to prioritise Pilliga, Pilliga West and Trinkey State Conservation Areas will have minor to marginal socio economic impacts upon local industries and communities.

Any source of change in a social system may have a direct or indirect (flow-on) effect throughout the system (Boudon, 1986). 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). As shown in **Figure 22**, 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 22: Effects of change on the social system

The extent to which local communities in the Brigalow Nandewar region are vulnerable to active and adaptive management of the 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).

10.2 Local industries

10.2.1 Timber industry

Active and adaptive management in the State Conservation Areas is likely to provide some minor benefits to 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 residues will provide marginal benefits to local communities.

For example, using the NRC's modelled scenarios for priority state conservation areas (**Section 9.1**), the production volumes could vary from 1,150 cubic metres per year (if only the densest class is treated) to 7,600 cubic metres per year (if both Class 3 and 4 are treated).

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.

Refer to **Attachment 19** 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 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 small 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 marginally improve the use of capital and may provide the mills with a better log mix. Improvements to the mills' production levels may also lead to a small increase in the number of hours worked by employees, resulting in small 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, increases in employment income are 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 most 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 marginally. 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 thinning, and the potential additional benefit of transporting this material, are likely to result in an increase in hours worked by existing employees. This could lead to minor increases in expenditure in Baradine, with indirect flow-on effects to nearby towns and regional centres. Minor expenditure could 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. The potential for this firm to pay these additional costs is not tested.

If the 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 may obtain minor benefits from an increase in the supply of non-production volumes, as there is some potential for bulloak to be promoted as a firewood species (see **Attachment 19** for further discussion).

Bioenergy and biofuels sector[37]

The use of non-production material generated by ecological thinning for electricity generation was explored as a potential future commercial opportunity in **Section 9.3.2**. Although markets for the use of biomass as fuel are developing, commercial opportunities are limited at present.

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. However, an ecological thinning program in the State Conservation Areas would need to be integrated with a thinning program in state forests to generate sufficient forest biomass for co-generation.

More information about potential commercial opportunities linked to the bioenergy and biofuels sector can be found in **Attachment 19**.

10.2.2 Grazing industry

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

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.

Benefits to graziers would need to be offset against grazing permit charges and additional overheads, including the costs of transport and the construction and maintenance of infrastructure including fences and watering points.

10.2.3 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.

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.

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

The 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.

10.2.4 Other potential effects

Prescribed burns are already being undertaken in the State Conservation Areas. There may be additional small-scale sporadic opportunities for employment and training in fire management if the NSW National Parks and Wildlife Service uses external contractors. This could include Aboriginal employment if Aboriginal burning techniques are developed and applied.

10.3 Sensitive local communities

Figure 23 shows the local communities in close proximity to the State Conservation Areas are:

- Baradine
- Coonabarabran
- Dubbo
- Gunnedah
- Gwabegar
- Narrabri.

Ecological thinning is likely to contribute short term to minor 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.

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. These firms employ around 20 people who reside in Baradine.

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 8.2 percent in 2006 to 11.8 percent in 2011) (Australian Bureau of Statistics, 2001, 2006, 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).

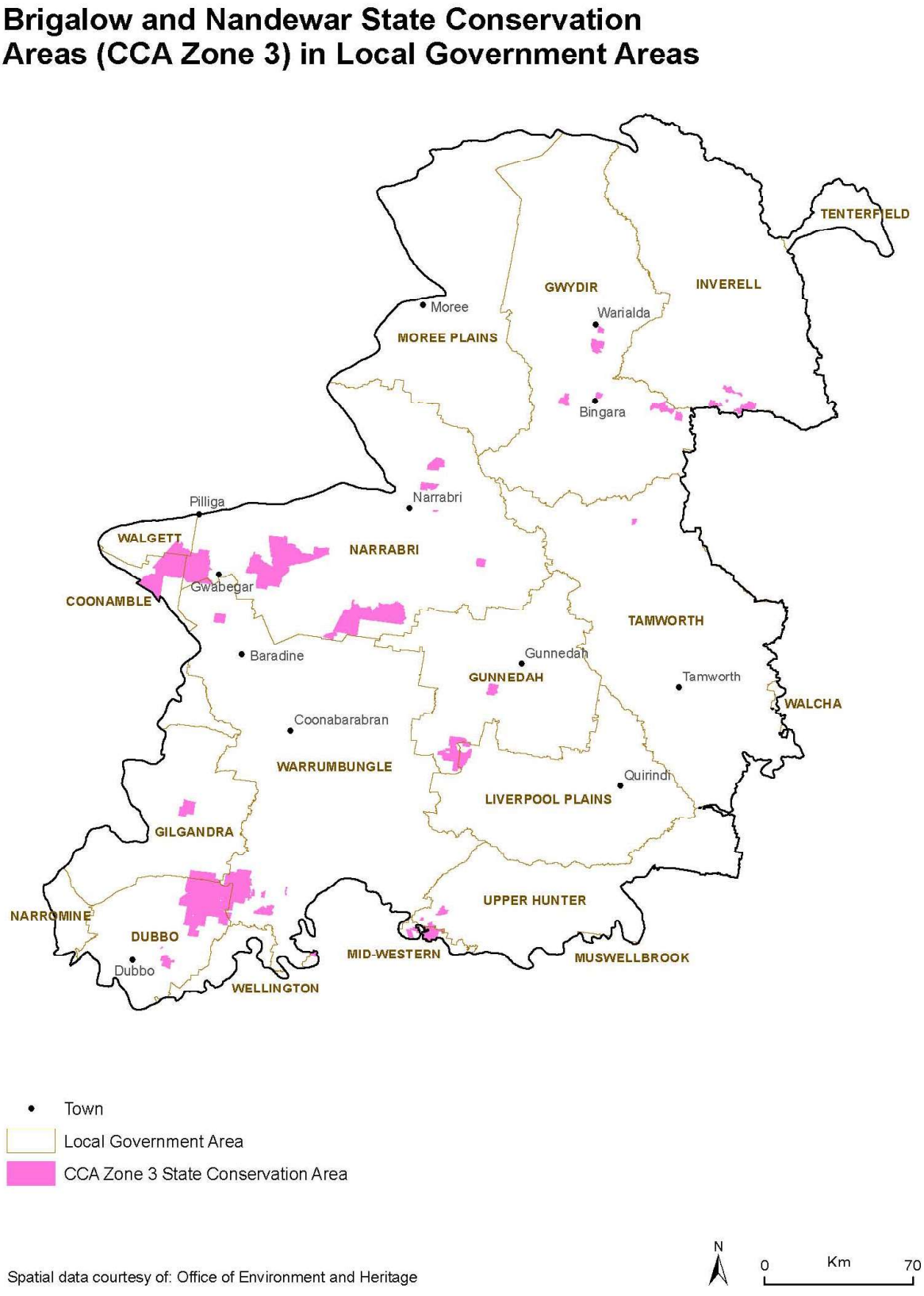

Figure 23: Map showing Local Government Area boundaries

10.3.1 Other local communities

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

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 10.2.1**, these firms employ between 20 and 25 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 10.6.1** for further discussion) (Narrabri Shire Council, 2007, 2009; Parsons Brinckerhoff Pty Limited, 2008).

10.4 Aboriginal communities and cultural values

10.4.1 Aboriginal cultural heritage

If active and adaptive management is implemented in priority state conservation areas (Pilliga, Pilliga West and Trinkey State Conservation Areas), it may affect communities represented on the Pilliga Gawambaraay Co-Management Committee, the Coonamble, Pilliga, Walgett, Wee Waa and Walhallow Local Aboriginal Land Councils, the Tubba-Gah people and the Gomeroi people. See **Attachment 11** for a map showing the location of the 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, 2002), 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.

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 12.3**). For instance, if sites occur near creeks these will be excluded from active management based on existing environmental and cultural management prescriptions.

10.4.2 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).

10.5 Effects on and around the State Conservation Areas

10.5.1 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.

Impacts will vary depending on the location and intensity of the active interventions applied. However, as noted in Attachment 11, the majority of tourism visits in the region occur in national parks that are in close proximity to caves or cultural sites, rather than in the 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.

10.5.2 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 the 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.

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 12.2**).

10.5.3 Neighbouring landholders

Active and adaptive management has the potential to have short-term impacts on neighbouring landholders, including:

- potential for increased noise resulting from harvesting and haulage machinery, human activity, vehicle movements and road requirements during ecological thinning
- reduced visual amenity associated with on-site retention of residues from ecological thinning, particularly larger log
- impacts if prescribed fire burns are not adequately controlled and fire escapes into neighbouring properties.

However, there are also likely to be long-term benefits for neighbouring landholders following active management. 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. The application of prescribed fire may also reduce the risk of uncontrolled fires in the State Conservation Areas impacting on neighbouring properties.

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

10.6 Effects on the region

10.6.1 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).

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, harvest and sawmilling employees) (Australian Bureau of Statistics, 2011b, 2013).

In contrast, 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.

11 Governance and accountability

11.1 Proposed governance framework

In **Section 6.4.1**, the NRC recommends that the Office of Environment and Heritage develop an Adaptive Management Plan for the Brigalow and Nandewar State Conservation Areas. The Adaptive Management Plan, and associated consultation, collaboration and accountability mechanisms, will require revision of the current governance framework for the State Conservation Areas. **Figure 24** summarises the NRC's proposed governance arrangements to support active and adaptive management of the State Conservation Areas. The proposed arrangements are discussed in more detail throughout the remainder of this section.

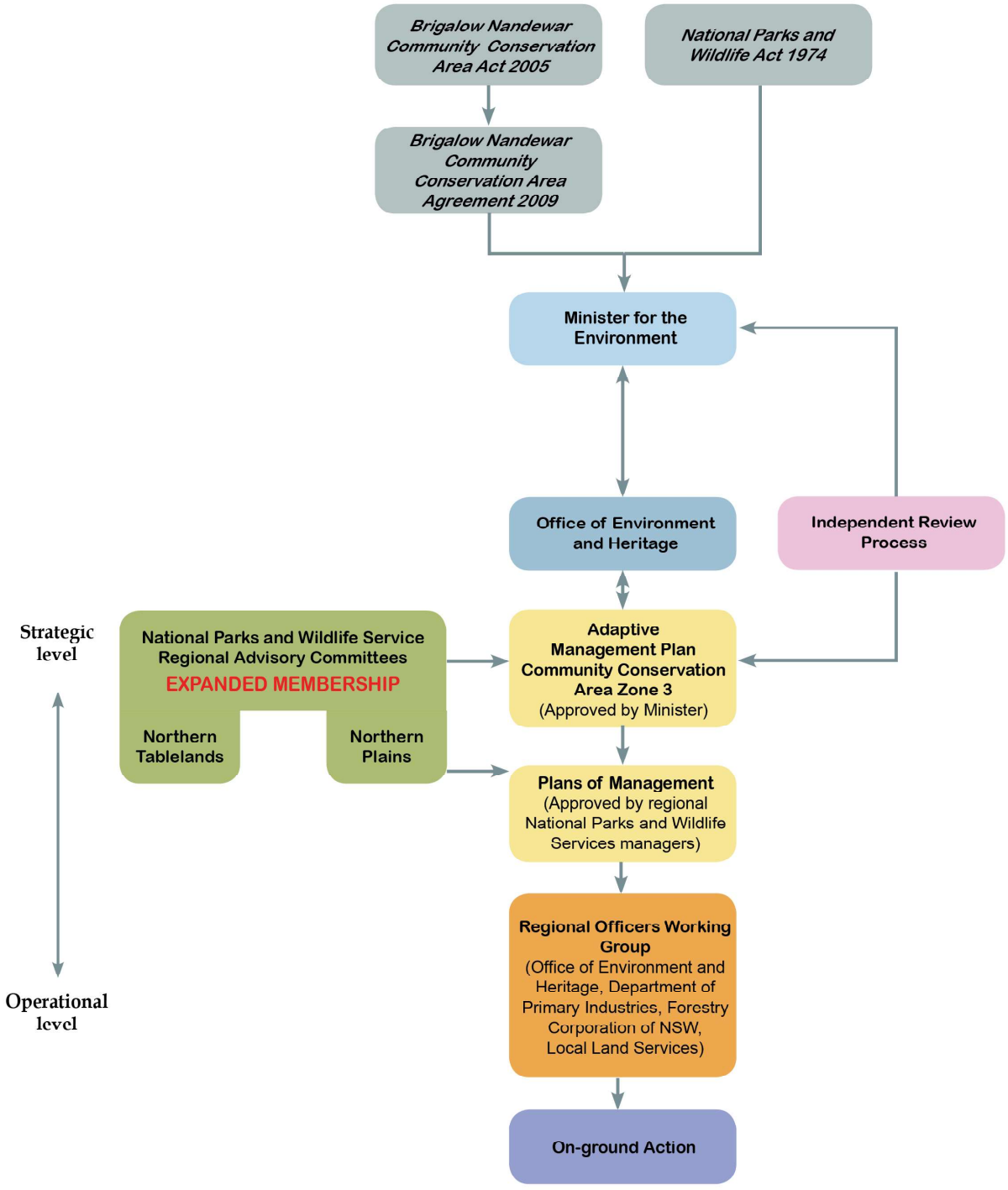

Figure 24: Proposed governance arrangements

11.1.1 Governance and accountability during planning

The Adaptive Management Plan for the State Conservation Areas should be prepared by 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).

As an additional accountability mechanism, the development and implementation of the Adaptive Management Plan should be subject to an independent review process (see **Figure 24**). 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 for the Environment should also seek advice from an independent reviewer before approving the plans.

National Parks and Wildlife Service should develop plans of management for the State Conservation Areas at the regional level, in accordance with the overarching Adaptive Management Plan and with input from the National Parks and Wildlife Service Landforms and Rehabilitation Team as appropriate.

Approval of the plans of management should be devolved to relevant National Parks and Wildlife Service regional managers. This would support devolved decision-making, reduce administrative complexity and promote more timely approval and implementation of plans. The *National Parks and Wildlife Act 1974* (NSW) would need to be amended to reflect the proposed changes to the approval process for the plans of management.

Stakeholder review and input into the Adaptive Management Plan and plans of management will be provided by the National Parks and Wildlife Regional Advisory Committees (see **Section 11.2**).

11.1.2 Governance and accountability during implementation

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.

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 harvesting 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 harvesting under an Integrated Forestry Operations Approval. Active management interventions such as ecological thinning are only to be carried out within the State Conservation Areas 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.

As described in **Section 9.2.1**, the NRC is recommending an outcomes based performance audit model is adopted for active management programs, including ecological thinning programs. As part of this model, the Office of Environment and Heritage should take steps to ensure that any contractors hired to undertake active management interventions are accountable for operating within specified prescriptions and guidelines. Appropriate assurance mechanisms also need to be in place, for example fines, mechanisms for contract termination and/or exclusion from tendering for subsequent contracts.

11.2 Streamlining stakeholder engagement

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, are informed by consultation with community stakeholders and technical experts, particularly stakeholders with expertise in active and adaptive management.

Table 30 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 30: 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* *Central West* *Namoi*	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.

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*.[38]

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

[38] NSW Government Question on Notice, 30 October 2013, Paper No. 175, *5143 Environment - Community Conservation Advisory Committee, answered 4 December 2013.

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 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.

11.3 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 believes the cross-tenure intent of the Brigalow and Nandewar Community Conservation Area has not been realised. The regulatory arrangements for the Community Conservation Area are still strongly linked to the existing regulatory framework for conservation and forestry tenure and management. In effect, zones within the Community Conservation Area are managed no differently to other conservation and forestry tenures found elsewhere in NSW.

During this review, the NRC has observed ongoing tensions amongst stakeholders about issues such as 'who owns and bears the problem' and who can provide the best solution. In these situations, Governments can be tempted to redress the omission of one group through policy iterations only to alienate others and reinforce tensions (Griffith et al., 2014).

The NRC is proposing that a Regional Officers Working Group is established, as shown in the proposed governance framework in **Figure 24**.

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 flexible, to capitalise on goodwill and co-operative relationships within the region.

11.4 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 (Lindenmayer & Likens, 2010; Wintle et al., 2010).

Figure 25 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).

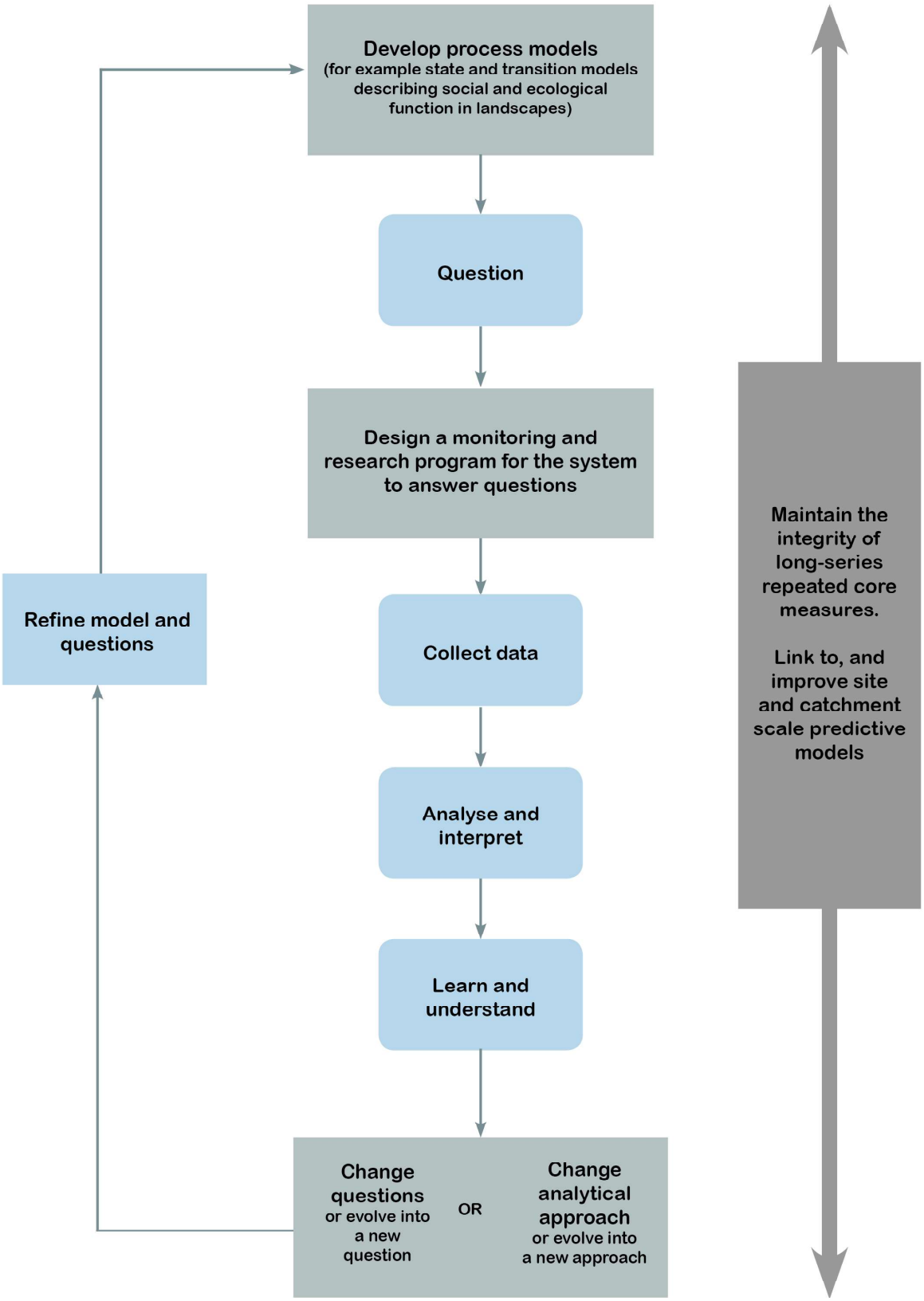

Figure 25: Adaptive monitoring and research framework (adapted from Lindenmeyer & Likens 2010)

11.4.1 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 cypress pine and bulloak) 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.

12 Legislative considerations

12.1 Legislative requirements and potential amendments

Implementing active and adaptive management in the 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 the 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*.

In making this decision the Director-General must also apply the overarching principles of ecological sustainable development. **Table 31** sets out an analysis of active and adaptive management options in the State Conservation Areas against ecologically sustainable development principles.

Table 31: Analysis of active and adaptive management in the State Conservation Areas against ecologically sustainable development principles

Ecologically sustainable development principles (Adapted from Section 3A of the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*)	Active and adaptive management in the State Conservation Areas
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 Section 3A of the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*)	Active and adaptive management in the 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.

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
- secondary commercial benefits are also permissible, provided the primary objective of the intervention is to improve ecological outcomes.

This advice is based on legal interpretation and has not been tested through case law. Therefore, to provide greater certainty for active and adaptive management in the State Conservation Areas, the NRC recommends the NSW Government make amendments to relevant NSW legislation. These are discussed in the following section.

12.1.1 Clarifying legal permissibility under NSW legislation

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 the State Conservation Areas, providing the primary ecological test has been met
- existing draft and final plans of management where the relevant Brigalow and Nandewar 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 the 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.

12.1.2 Barriers within national legislation

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.[39] 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.[40] 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.

The Australian Government is reviewing the Renewable Energy Target scheme. The Renewable Energy Target Expert Panel, in its report released on 28 August 2014, supports the Australian Government's election commitment to reinstate native forest wood waste as a renewable energy source and proposes it be implemented through the reintroduction of relevant regulations in place prior to 2011. The Australian Government is currently considering the findings of the Panel's review.

It is recommended that the NSW Government support the Renewable Energy Target Expert Panel's recommendation to the Australian Government on amendments to the *Renewable Energy (Electricity) Regulations 2001* (Cth) to recognise the use of ecological thinning residues under the Renewable Energy Target.

12.1.3 Devolved decision-making

The *National Parks and Wildlife Act 1974* (NSW) currently requires plans of management for the State Conservation Areas to be prepared by the Director-General and approved by the Minister for the Environment.[41] These requirements are administratively inefficient and do not support decision making at the local and regional scale.

Instead, the NRC is proposing that:

- the Minister for the Environment approve the overarching Adaptive Management Plan that will guide the development of plans of management for the State Conservation Areas
- the *National Parks and Wildlife Act 1974* (NSW) be amended to allow approval of plans of management for the State Conservation Areas to be devolved to relevant National Parks and Wildlife Service regional managers.

12.1.4 Policy and planning

Draft plans of management should be prepared for all of the State Conservation Areas, with priority given to those listed in **Section 5.7.4**.

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39 *Renewable Energy (Electricity) Amendment Regulations 2011 (No. 5)* (Cth)
40 Section 8 *Renewable Energy (Electricity) Regulations 2001* (Cth)
41 Sections 72 and 73B.

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.

12.1.5 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, 2012c). If targeted grazing is identified as an appropriate management intervention in Leard State Conservation Area, the plan of management must be amended to permit targeted grazing pursuant to section 73B of the *National Parks and Wildlife Act 1974* (NSW).

12.2 NSW regulatory assessments and approvals

The assessments and approvals set out in **Table 32** are currently required before active and adaptive management activities can be implemented in the 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 Heritage, 2014a). Statutory requirements for assessments and approvals should be confirmed before any operational activities can occur.

Table 32: Required assessments and approvals

Relevant Act	Requirements
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.

Relevant Act	Requirements
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 12.1** 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 12.3** 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 the 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.
Rural Fires Act 1997 (NSW)	▪ Determine whether activities are likely to cause bushfires or increase danger of spread of bushfires on or from the 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.

12.3 Determining potential impacts on Aboriginal cultural heritage

As outlined in **Table 32**, 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 the 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 the 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 33**)
- 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).

12.4 Commonwealth statutory processes

The Commonwealth statutory processes set out in **Table 33** are currently required before active and adaptive management activities can be implemented in the State Conservation Areas.

Table 33: 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 of the 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.

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 was released for public exhibition by the Commonwealth on 14 May 2014, with submissions closing on 13 June 2014. The draft agreement applies predominantly to major project approvals and threatened species licences 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.

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Part IV – 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 Zone 3)	Size (hectare)	Date created	Plan of management	Statement of management intent	Prioritised regional pest program	Fire management strategy
Adelyne	148	1/01/2011	No	Yes - June 2014	Yes	Jun 2012
Beni	1,849	1/12/2005	No	Yes - June 2014	Yes	Jun 2009
Biddon	3,352	1/12/2005	Yes – Oct 2012	NA	Yes	Apr 2013
Bingara	1,979	1/12/2005	No	Yes - June 2014	Yes	Jun 2008
Bobbiwaa	2,688	1/12/2005	No	Yes - June 2014	Yes	Apr 2009
Bullawa Creek	99	1/12/2005	Yes – Nov 2012	NA	Yes	Sept 2008
Cobbora	2,261	24/12/2010	No	Yes – May 2014	Yes	No
Durridgere	6,172	1/12/2005	No	Yes - June 2014	Yes	Jun 2009
Goodiman	569	1/12/2005	No	Yes - June 2014	Yes	Jun 2009
Goonoo	54,522	1/12/2005	No	Yes - June 2014	Yes	Aug 2009
Goonoowigal	1,055	1/12/2005	No	Yes - June 2014	Yes	Jun 2008
Gwydir River	2,607	1/12/2005	No	Yes - June 2014	Yes	Aug 2006
Killarney	1,858	1/12/2005	No	Yes - June 2014	Yes	Apr 2009
Leard	1,176	1/12/2005	Yes – Nov 2012	NA	Yes	Apr 2009
Merriwindi	1,730	1/12/2005	No	Yes - June 2014	Yes	Oct 2009
Pilliga	33,386	1/12/2005	No	Yes - June 2014	Yes	Jun 2009
Pilliga East	24,669	1/12/2005	No	Yes - June 2014	Yes	May 2012
Pilliga West	34,415	1/12/2005	No	Yes - June 2014	Yes	Jun 2009
Tingha Plateau	3,414	1/01/2011	No	May – June 2014	Yes	Aug 2008

Trinkey	10,229	1/12/2005	Draft – Feb 2012	NA	Yes	Sept 2013
Warialda	2,913	1/12/2005	No	Yes - June 2014	Yes	Jun 2008
Wondoba	1,663	1/12/2005	Draft – Feb 2012	NA	Yes	Sept 2013
Woodsreef	331	1/01/2011	No	May 2014	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.

Overall the NRC undertook six 'streams' of spatial analysis:

1. **Predict location of cypress pine and bulloak –** using a range of spatial and other datasets across 23 State Conservation Areas
2. **Identify, characterise and map canopy density surfaces –** using ADS40 imagery across 23 State Conservation Areas
3. **Research and develop bulloak canopy density surfaces** – using ADS40 imagery across 5 State Conservation Areas
4. **Identify and map sensitive cultural and environmental areas –** using a range of spatial and other datasets across 23 State Conservation Areas
5. **Calculate available white cypress pine timber volumes** – using ADS40 imagery and LiDAR data across 5 State Conservation Area
6. **Describe vegetation structure** – using LiDAR data across 5 State Conservation Area

Predicting the location of cypress pine and bulloak

The NRC used statistical analysis (Generalised Regression Analysis and Spatial Prediction (GRASP); Lehmann, Leathwick, & Overton, 2004; Lehmann, Overton, & Leathwick, 2002) and spatial datasets (topography, hydrology, landscape substrate, climate and vegetation) to model and predict the likely location of white cypress pine, black cypress pine and bulloak in the State Conservation Areas.

This complements the ADS40 analysis by helping to distinguish where dense areas of black cypress pine, white cypress pine and bulloak are likely to occur.

Identifying, characterising and mapping canopy density surfaces

For this review, the NRC selected existing 'off-the-shelf' 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 cypress pine.

The NRC used ADS40 imagery to detect spectral signatures of cypress pine and bulloak to develop maps to identify areas where these species are likely to be more or less dense across all State Conservation Areas.

The NRC's initial analysis aimed to detect white cypress pine alone. However, the NRC found the leaves of white cypress pine and black cypress pine have similar reflective spectral signatures. The methodology also captures bulloak in some areas as this species also has a similar spectral signature to both white and black cypress pine. This means the final mapping captures areas where all three species are more likely to be relatively more or less dense.

This analysis allows for a complete census rather than the traditional approach of describing vegetation characteristics from samples alone. Data collection by census avoids problems with sampling design and execution, inference, and error projections that are common in field assessments.

The NRC selected existing 'off-the-shelf' 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.

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 and black cypress pine (*Callitris glaucophylla and Callitris endicheri)*, bulloak (*Allocasuarina luehmannii)*, rough barked apple (*Angophora floribunda)* and *Acacia* species within image classification
- providing stronger differentiation between *Eucalyptus* species to generate robust eucalypt to white cypress pine ratios
- accounting for disturbances after the capture date of remotely sensed data.

Researching and develop bulloak canopy density surfaces

The NRC conducted research and development to explore whether the spectral signature of bulloak could be distinguished from white and black cypress pine.

The NRC applied a similar analysis and method to identify, characterise and map canopy density surfaces for cypress pine using ADS40 imagery. However, further processing techniques and additional spectral bands were applied to detect bulloak.

The NRC suggests this analysis could be applied across all State Conservation Areas, noting that processing off-the-shelf ADS40 imagery will incur additional costs.

Identify and map sensitive cultural and environmental areas

The NRC used a range of spatial and other datasets to identify and map sensitive cultural and environmental areas in each State Conservation Area (see **Table A3.1** and **Table A3.4**). The NRC used this information to exclude these areas when calculating white cypress pine timber volumes.

However, these spatial layers and maps are likely to be useful tools to support decision making and management in the State Conservation Areas.

Table A3.1: Summary of sensitive environmental and cultural attributes

Environmentally and culturally sensitive attributes	Example	Action
Aboriginal heritage	Aboriginal Object or Place, burial site, scarred or carved tree, Aboriginal Place	Exclude active management within specified areas (for example, buffers)
	Likely occurrence of heritage items	Identify and manage risks
European heritage	Heritage items such as huts and sheds	Exclude active management within specified areas (for example, buffers)
Waterways	Streams and wetlands	Exclude active management within specified areas (for example, buffers)

Environmentally and culturally sensitive attributes	Example	Action
Threatened fauna	Potentially over 40 species and their habitats to consider, such as barking owl nest sites and roosts for certain bats and birds	Exclude active management within specified areas (for example, buffers) Identify and manage risks
Threatened flora	Potentially up to 17 species to consider such as *Homoranthus darwinioides* and *Boronia granitica*	Exclude active management within specified areas (for example, buffers) Identify and manage risks
Endangered Ecological Communities	White box, yellow box, blakely's red gum, box gum woodland and inland grey box woodland	Exclude active management within specified areas (for example, buffers) Identify and manage risks
Special landscape features	Caves, cliffs, heathlands and dams	Exclude active management within specified areas (for example, buffers)
Soils	Highly erodible soils	Identify and manage risks

Calculating available white cypress pine timber volumes

The NRC also captured new Light Detection and Ranging (LiDAR) data over 5 State Conservation Areas to estimate timber volumes (in combination with ADS40 imagery). LiDAR is a technology that uses laser pulses to generate large amounts of data about the physical layout of terrain and landscape features (CSIRO, 2014).

The LiDAR analysis also measures tree populations (a census type approach), rather than relying on sampling a population alone. However, capturing new LiDAR data across all 23 State Conservation Areas was cost prohibitive, so LiDAR data was captured over five State Conservation Areas.

Describing vegetation structure

The NRC also used LiDAR data to analyse and describe stand structure and variability of vegetation across five State Conservation Areas: Bobbiwaa, Killarney, Merriwindi, Pilliga West and Trinkey State Conservation Areas.

Table A3.2 outlines the steps undertaken in the NRC's analysis, the resultant outputs and links to more detailed information.

Table A3.2: Overview of spatial analysis

Step		Description	References and further links
Predict likely location of cypress pine and bulloak			
1	**Prepare spatial data to support model**	▪ Predictor layers (environmental variables) compiled, assessed and prepared prior to habitat modelling. ▪ Environmental variables included topographic, hydrologic, landscape, substrate, climatic and vegetation information. ▪ Variables were represented by categorical datasets (e.g. distribution of vegetation communities) as well as continuous datasets representing indicator values (e.g. temperature) or distance to selected features (e.g. distance to drainage lines).	▪ (Eco Logical Australia, 2014b)
2	**Prepare species records**	▪ Species presence and absence records were sourced from the Atlas of NSW Wildlife database records in the OEH VIS database. ▪ Datasets included 1,171 records (presence and absence) for selected species occurring within the study area. ▪ Data were generally collated from floristic surveys, so absence data were interpreted as 'actual absence' of the species at the record location. ▪ Records were inspected and filtered based on record duplication and spatial independence, spatial accuracy, currency and intersection with environmental variables.	▪ (Eco Logical Australia, 2014b)

Step		Description	References and further links
3	**Generate models**	▪ GRASP (Generalised Regression Analysis and Spatial Prediction) software, and Generalised Additive Models (GAM) determined the relationships between species records and spatial predictors. The software was used both as a module in the S-Plus Statistical Package to generate the models, and as an extension in ArcGIS to derive the spatial representation of the models. ▪ A step-wise binomial modelling procedure identified the strongest statistical relationships between records and environmental variables using a step-wise procedure that included all ecologically relevant environmental variables and used an analysis of variance (F-test) to identify which combination of variables produced the strongest relationship to the species data. ▪ Species presence/absence histograms and graphs for each environmental variable were reviewed as a first data exploration step. This step, alongside consideration of the species ecological requirements, was used in refinement of models.	▪ (Eco Logical Australia, 2014b) ▪ (Lehmann et al., 2004, 2002)
4	**Evaluate models**	▪ Models evaluated by assessing ecological, spatial and statistical appropriateness, specifically through predicted habitat distribution, validation and cross-validation statistics and variable contribution.	▪ (Eco Logical Australia, 2014b)
5	**Map models**	▪ Models are represented by spatial prediction surfaces (showing predicted relative probability of potential habitat), and validation and contribution statistics and graphs.	▪ (Eco Logical Australia, 2014b) ▪ Maps in (Natural Resources Commission, 2014)
Identify, characterise and map canopy density surfaces			
1	**Acquire and processADS40 images**	▪ 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, 2014) ▪ See **Table A3.2** for discussion on issues and confidence levels for spatial products ▪ ADS40 aerial image in (Natural Resources Commission, 2014)

Step		Description	References and further links
2	**Identify presence/absence of cypress pine**	▪ Red Green Blue images classified into new composite bands using a series of algorithms to generate a 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 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, 2014) ▪ (Eco Logical Australia, 2014c)
3	**Describe 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 cypress pine stand density. ▪ The Canopy Cover Percentage surface raster layer represents the proportion of area covered by 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) ▪ Maps in (Natural Resources Commission, 2014)

Step		Description	References and further links
4	**Classify 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) ▪ (Eco Logical Australia, 2014c). ▪ Maps in (Natural Resources Commission, 2014)
Research and develop bulloak canopy density surfaces			
1.	**Acquire and processADS40 images**	▪ ADS40 Imagery provided by LPI and previously ortho-rectified and processed by RPS Mapping. The imagery has four bands; Red, Green, Blue and Near-Infrared and a ground pixel spacing of 0.5 metres.	▪ (RPS, 2014)
2.	**Decorrelate image**	▪ TNTmips software generated four decorrelated bands from the 4-band ortho-rectified ADS40 images. ▪ Perform principle components analysis to stretch all four principle components from 0 – 255. ▪ Reverses the principle components transformation on the stretched principle components to produce decorrelated image bands to provide greater spectral discrimination between different ground cover types.	▪ (RPS, 2014)

Step		Description	References and further links
3	**Segment image**	▪ Decorrelated images were segmented using the open source software Orfeo Toolbox using a minimum object size of 10 square metres. ▪ Segmentation image converted to vector polygons and the mean value for each decorrelation band was computed for each polygon. ▪ Polygons were then converted back to rasters, one for each band, with the pixel values representing the mean value within each polygon.	▪ (RPS, 2014)
4.	**Classify spectral signatures**	▪ An automatic (K-Means) classification was applied to the segmented image bands. ▪ Up to 75 spectral signatures were generated for each image. The classifications are examined closely in reference to the multi-spectral images and signatures interpreted to represent bulloak are combined to produce several classes representing bulloak patches. ▪ Ambiguous areas marked for field validation.	▪ (RPS, 2014)
5	**Seam lines**	▪ Image seam lines were created to extract the most central portion of the overlapping ADS40 strips. ▪ Image quality deteriorated towards the edge of images and trees were seen more from the side, distorted as the view angle becomes less vertical. ▪ Seam lines were drawn approximately through the centre of the area of overlap between adjacent ADS40 strips to optimise the results. These were formed into polygons that were used to extract the central portion of the ADS40 images, removing parts of the image with the highest off-nadir view angles. ▪ A total of 6 image segments were used for this study.	▪ (RPS, 2014)
6	**Describe canopy in continuous surface layer**	▪ Binary masks were converted to a continuous Canopy Cover Percentage surface raster layer to provide a surrogate estimate of stand density ▪ The Canopy Cover Percentage surface raster layer represents the proportion of area covered by bulloak pixels within a moving circular search window. These continuous variable surfaces contained pixel values ranging from 0 to 100 percent.	▪ (RPS, 2014)

Step		Description	References and further links
7	**Classify 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.	▪ RPS ▪ Maps in (Natural Resources Commission, 2014)
Identify and map sensitive cultural and environmental areas			
1.	**Acquire spatial data**	▪ Spatial data relevant to each criterion in the rule set was identified and sought from relevant NSW Government agencies (**Table A3.3**).	▪ (Eco Logical Australia, 2014a)
2	**Develop rule sets**	▪ Develop list of rule sets and management actions for environmental and cultural attributes (see **Table A3.1** and **Table A3.4**). ▪ Each rule set was implemented through spatial analyses in ArcGIS including: - applying buffers around species records in accordance with the defined rule sets - assigning stream order to a detailed drainage layer (derived from LiDAR) and then applying the relevant buffer to nominated stream orders as per the defined rule sets - assigning EEC status to regional vegetation communities - applying buffers around nominated special landscape features as per the defined rule sets - Assigning a risk value on highly erodible soil types.	▪ (Eco Logical Australia, 2014a)
3	**Map environmental and cultural values**	▪ All of the above layers were merged into a spatial layer and mapped.	▪ (Eco Logical Australia, 2014a) ▪ Maps in (Natural Resources Commission, 2014)

Step		Description	References and further links
Calculate available white cypress pine timber volumes			
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 25 metre 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, 2014a)
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 coincide with LiDAR-defined crowns. This enables correct attribution of LiDAR derived heights to white cypress pine crowns once these have been identified in the images.	▪ (Forestry Corporation of NSW, 2013)

Step		Description	References and further links
C	**Calculate gross timber resources**	▪ Total stem volumes are calculated in the Forestry Corporation of NSW's inventory database 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 in 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, 2002) ▪ (Forestry Corporation of NSW, 2014) ▪ (Eco Logical Australia, 2014a)
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, 2014a)
Describing vegetation structure			
1	**Develop height surface**	▪ 'Smooth' canopy surface layer and apply averaging algorithm in ArcGIS to each cell that considered the 'average' height of all cells within a 25m radius around each tree.	▪ (Eco Logical Australia, 2014a)
2	**Generate canopy height charts**	▪ Generate cumulative canopy-height charts white cypress pine and non-white cypress pine 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 FCNSW), then plot the total percentage return (mask and non-mask) from ground level to height increment. ▪ Generate percent-cover charts to describe the relative contribution of white cypress pine cover and non-white cypress pine cover within four height bands: < 3m; 3-12m; 12-22m; and ≥ 22m.	▪ (Eco Logical Australia, 2014a)

Step		Description	References and further links
3	**Characterise and describe stand structure**	▪ Two surfaces were derived: - smoothed cover surfaces for white cypress pine in each of the following height classes: 3-12 metres; 12-22 metres; greater than 22 metres; all height classes; and - smoothed cover surfaces for non-white cypress pine in each of the following height classes: less than 3 metres; 3-12 metres; 12-22 metres; greater than 22 metres; all height classes. ▪ The two surfaces covering all height classes were converted to 10 by 10 metre grids then merged to provide a characterisation of broad structure, in terms of absolute and proportional cypress – non-cypress mix throughout the forest. ▪ Each of the eight cover layers associated with a specific height band were also converted to 10 by 10 metre grids, then combined to identify all possible combinations of white cypress pine and non-white cypress pine cover in different height bands, thus presenting a much finer-scale characterisation of forest structure. ▪ The area of each class was tallied, and examples of common structural units were described.	▪ (Eco Logical Australia, 2014a) ▪ Graphs in (Natural Resources Commission, 2014)

Table A3.3: 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

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
Historic 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 and 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 record (less than 20yrs age with reliability level 1-5) Pilliga mouse (*Pseudomys pilligaensis*) - 200 metres Squirrel glider (*Petaurus norfolcensis*) - 250 metres Barking owl (*Petaurus norfolcensis*) - 500 metresMasked owl (*Tyto novaehollandiae*) - 2 kilometres	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 Turquoise parrot nest - 50 metres Masked owl roost - 100 metres Barking owl major roost - 100 metres	Integrated Forestry Operations Approval (cl.246) Private Native Forestry Code of	Exclude management	Field Survey	OEH

Theme	Rule set criterion	Reference	Action	Data	Custodian
	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 - 100 metres Yellow-bellied glider den trees - 50 metres Osprey nests - 100 metres	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 water bodies 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 greater 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 (those with a 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.

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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 (Niche Environment & Heritage)	Forest wildlife scientist
Dr Anne Kerle (Kerle Environmental)	Ecologist
Dr Frank Lemckert (Niche Environment & Heritage)	Terrestrial wildlife ecology
Andrew Morton (URS)	Forest management and commercial opportunities
Kim Piercy (RPS Spatial)	Spatial analysis
Colin Stucley (Enecon)	Bioenergy
Dr Russell Turner (Remote Census)	Spatial Analysis
Dr Julian Wall (Eco Logical Australia)	Landscape ecology and spatial analysis

Attachment 5 -List of submissions to draft report

Submissions received			
Submissions from organisations			
1.	Association for Berowra Creek Inc.	20.	Kevin Anderson MP – The Nationals
2.	Australasian Native Orchid Society Inc.	21.	Landmark Ecological Services Pty Ltd
3.	Australian Orchid Council	22.	Mudgee District Environment Group
4.	Baradine & District Progress Association	23.	Narrabri Shire Council
5.	Bilby Blooms	24.	National Parks Association of NSW
6.	Blue Mountains Conservation Society Inc.	25.	National Parks Association of NSW, Armidale Branch
7.	Central West Environment Council	26.	National Parks Association of NSW, Tamworth-Namoi Branch
8.	Clarence Environment Centre	27.	Nature Conservation Council of NSW
9.	Country Women's Association of NSW	28.	North West Local Land Services
10.	Country Women's Association of NSW, Baradine Branch	29.	North West Ecological Services
11.	Dr Mehreen Faruqi MLC – The Greens	30.	NSW Farmers
12.	Dubbo Field Naturalist and Conservation Society	31.	NSW Forest Products Association Ltd
13.	Environmental Defender's Office NSW	32.	Parry Logistics
14.	Forestry Corporation of NSW	33.	St John's Catholic Primary School
15.	Friends of the Pilliga	34.	Stop the Coal Seam Gas Blue Mountains
16.	Gunnedah Shire Council	35.	The Colong Foundation of Wilderness
17.	Hunter Environmental Lobby Inc.	36.	The Envirofactor Pty Ltd
18.	Illawarra Birders Inc.	37.	Tubba-Gah Aboriginal Corporation
19.	Institute of Foresters of Australia		
Submissions from individuals			
1.	A J Hallman	4.	Alan Mewett
2.	Abigail Humphreys	5.	Alexander Dudley
3.	Alan Carpenter	6.	Alison Clouston and Peter Boyd

Submissions received			
7.	Andrew Mortlock	34.	Dr Margaret Lorang
8.	Anna Ingham	35.	Dr Peter Barker
9.	Ashley Love	36.	Emma Rooksby
10.	Barbara Wakefield	37.	Felicity Davis
11.	Barry Tomkinson	38.	Frances Scarano
12.	Bart Beech	39.	Gary Schoer
13.	Bill Harvey	40.	Gerry McGilvray
14.	Boaz Magal	41.	Gigi Levins-skehill
15.	Bob Taffel	42.	Graeme Batterbury
16.	Caroline Goosen	43.	Ian Olsen
17.	Catherine Vaubell	44.	Ian Tanner
18.	Christine Buckridge	45.	Ifeanna Tooth
19.	Claire Bettington	46.	Jack Flanagan
20.	Clare Milledge	47.	Jacqueline Reid
21.	Colin Walters	48.	Jane Canfield
22.	Dale Curtis	49.	Jane Dargaville
23.	Daryl Morris	50.	Jane Harding
24.	David Butler	51.	Janelle French and Narelle Robinson
25.	David Hufton	52.	Janet Harwood
26.	David Johnston	53.	Janet Mayer
27.	David Paull	54.	Janice Hosking
28.	David Whitelaw	55.	Jennifer Brewer
29.	Denise Turner	56.	Jessica Mary Hanson
30.	Dörte Planert	57.	Jessica Murphy
31.	Doug Reckord	58.	Jo Lewis
32.	Dr Haydn Washington	59.	Joel Robinson
33.	Dr Ian Baird	60.	John Bennett

Submissions received			
61.	John Crouch	88.	Marie Morris
62.	John Robens	89.	Mark Graham
63.	Joy Williams	90.	Mark Jones
64.	Julie Marlow	91.	Marnie Cotton
65.	Julie Smith	92.	Matthew Hilton
66.	Julius and Felicity Timmerman	93.	Matthew Lyons
67.	Karen Joynes	94.	Maureen Grant
68.	Karen McLaughlin	95.	Maxine McKinley
69.	Keith Muir	96.	Miguel Heatwole
70.	Kerrie Lander	97.	Neville Burns
71.	Kevin McDonnell	98.	Nigel Tanner
72.	Kevin Taylor	99.	Pamela Reeves
73.	Lachlan Garland	100.	Paul Vale
74.	Leonie Kemp	101.	Peggy Goldsmith
75.	Leslie Anne Reddacliff	102.	Peter Maslen
76.	Linda Burns	103.	Peter W. Green
77.	Lois Carson	104.	Renee Doyle
78.	Lois Katz	105.	Rhonda Green
79.	Luke Andrews	106.	Rhonda Green 2
80.	M O'Neill	107.	Richard Reeg
81.	Madi Maclean	108.	Richard Sams
82.	Mal Anderson	109.	Richard Savage
83.	Malcolm Fisher	110.	Robert Bertram
84.	Manfred Tettweiler	111.	Robert Harding
85.	Marg Mclean	112.	Roger Bigland
86.	Margaret Anne Beal	113.	Roman Suwald
87.	Margaret Hilder	114.	Rosemary Morrow

Submissions received			
115.	Rosie White	125.	Terry Holdom
116.	Ruth Haig	126.	Thomas Coley
117.	Sally Townley	127.	Timothy Bidder
118.	Sandra Heuston	128.	Tjoan Lie
119.	Sean Corrigan	129.	Toni Diane Conley
120.	Sophia Dunn	130.	Troy Rosenberg
121.	Stephen Lord	131.	Warren Beaumont
122.	Su Li Sin	132.	Wendy Whitton
123.	Sue Baker	133.	William Harvey
124.	Taylor family	134.	Yvonne Langshaw

Note: The submissions listed above are available in full at www.nrc.nsw.gov.au. The NRC also received a further four submissions that were requested to remain confidential and have not been placed on the website.

Attachment 6 - Summary of stakeholder feedback

The Natural Resources Commission (NRC) invited public submissions on its 'Draft report - Active and adaptive cypress management in the Brigalow and Nandewar State Conservation Areas – June 2014'. The NRC appreciates the time and effort that went into all submissions, and would like to thank all those who contributed to the review.

Submissions analysis

The submissions process generated 175 submissions from individuals, industry representatives and groups, environment groups and professionals, individual community members, Aboriginal groups and local and regional government organisations, represented in **Figure A6.1**. The submissions can be accessed through the NRC website (except for those requested to remain confidential). http://www.nrc.nsw.gov.au/Workwedo

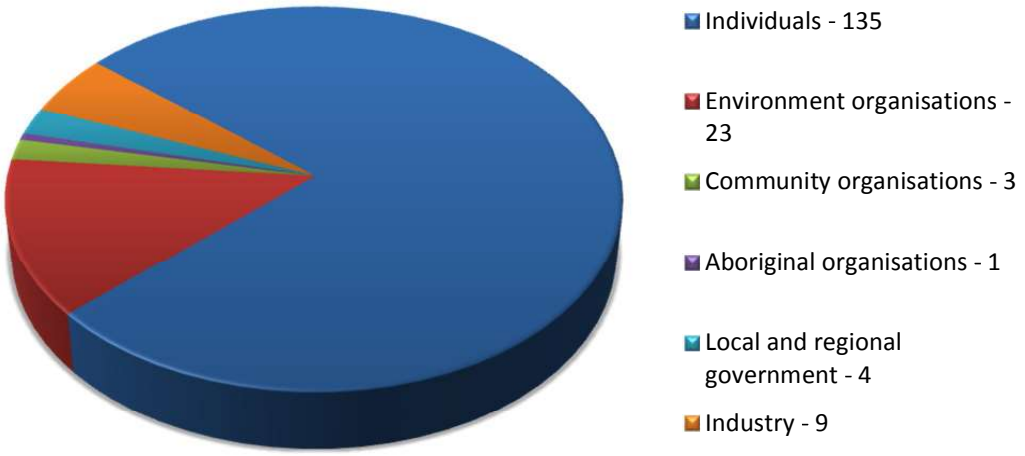

Figure A6.1: The 175 stakeholder submissions received by category

The stakeholder feedback received demonstrates the strongly held and divergent views on public land management in the Brigalow and Nandewar region. Submissions included arguments for and against the NRC draft report recommendations, active and adaptive management, and the specific active management options.

Some submissions were highly supportive of the recommendations. Other stakeholders were very concerned about the risks around active management, and that it would set a precedent for ecological thinning and grazing activities to be undertaken in other protected areas in NSW. Some submissions did not agree that dense cypress pine is a problem that needs to be addressed; instead, proposing that dense stands of vegetation are a natural part of the landscape.

Strong support for the recommendations was received mostly from local community members, local and regional government organisations, and local industry representatives and groups. Opposition to the report recommendations was mainly received from individuals, environmental organisations and environmental professionals.

Of the submissions received, 93 were based on form letters written by the National Parks Association of NSW, The Colong Foundation for Wilderness and the Nature Conservation Council of NSW. These stakeholders were predominately opposed to the NRC's recommendations, apart from some support for the use of low intensity prescribed burning. The Baradine and District Progress Association submitted a petition with 112 signatures from local community members in support of the NRC's recommendations.

Regional workshops

The NRC held workshops with regional stakeholders in July 2014 to discuss the findings and recommendations presented in the draft report. These workshops included:

- local government, Local Land Services and regional bodies
- local industry
- local environment groups
- the National Parks Northern Plains Regional Advisory Committee and National Parks and Wildlife Service Staff.

In this forum, stakeholders raised a number of questions and issues; these issues are included in this summary.

Principles of active and adaptive management

Support for active and adaptive management

Stakeholders who expressed support for the principles of active and adaptive management see this management approach as the best way to achieve ecological benefits alongside social and economic outcomes. Many of these stakeholders viewed the report as a practical and pragmatic way to manage these forests.

Stakeholders indicated support for:

- the inclusion of adaptive management principles in plans of management
- the consolidation of the State Conservation Areas within plans of management
- National Parks and Wildlife Service staff having discretion to use adaptive management as part of their management tools.

Stakeholders suggested that to implement adaptive management, land managers require flexibility in decision making.

Some stakeholders also noted that the State Conservation Areas have in the past provided economic value to the Brigalow and Nandewar region. Questions regarding the specific implementation of active and adaptive management included:

- who will determine benchmarks and outcomes, develop management plans and implement the actions?
- will baseline studies be conducted prior to implementing active management?
- to what extent will management or implementation be outsourced?

- will there be adequate resources for planning, implementation, monitoring and evaluation, risk management and accountability activities?
- will there be sufficient time for monitoring and evaluation of outcomes in order to inform ongoing decision making?
- who will audit and oversee implementation?

A few of these stakeholders expressed concern about outsourcing active and adaptive management, and that decisions could be influenced by commercial drivers instead of conservation based decision making.

In addition, some stakeholders supported active and adaptive management in principle, but were opposed to specific active interventions, particularly ecological thinning. These concerns are discussed in later sections of this summary.

Arguments against active and adaptive management

Stakeholders that did not support the implementation of active and adaptive management expressed strong opposition to the draft recommendations. In some cases, stakeholders were opposed to management interventions of any kind being implemented in the State Conservation Areas. Some endorsed the current management activities and were opposed to any changes.

A key concern was that undertaking active management in the State Conservation Areas would set a precedent for active management activities, in particular ecological thinning, being implemented in other reserves and national parks throughout NSW.

Concerns raised about the implementation of active and adaptive management include:

- that the environment will be opened up to damaging activities
- that, if management interventions are required, decisions about interventions should have a scientific basis, and the interventions should be targeted and conducted over short timeframes
- that the proposed planning and implementation cycle is inadequate to monitor the response of white cypress pine to management activities.

Some stakeholders were opposed to active and adaptive management as they felt it contradicted their understanding of ecologically sustainable development principles. They quoted the precautionary principle and felt that this principle advises taking a cautious approach where there is uncertainty about the potential outcomes from actions.

Requests for further information

Some stakeholders requested a clearer definition of active and adaptive management, including further explanation of how the recommendations will balance regional conservation outcomes with economic outcomes.

Stakeholders that supported active management suggested that further education for the wider community was needed to build on their understanding of how these management actions benefit white cypress pine forests.

Other stakeholders suggested that while the aim of adaptive management to improve biodiversity outcomes in the State Conservation Areas is sound, the science to support the proposed active management interventions is insufficient. Some recommended that adaptive management of the State Conservation Areas include extensive monitoring, such as flora and fauna surveys to monitor biodiversity outcomes.

It was noted by some stakeholders that natural climate cycles, or other disturbances such as fire, could deliver the desired outcomes of active and adaptive management without removing nutrients from the forest systems. They requested further information be provided on whether natural disturbances can achieve these outcomes in the State Conservation Areas, and if so, they could be an alternative to active management.

A few stakeholders suggested the combined impact of active management and the proposed coal seam gas developments in the State Conservation Areas should be investigated. They requested the report explore the effects of these operations on the environmental values of the region.

Management options

Mixed views were received on the active management activities proposed in the report. Some stakeholders saw ecological thinning, grazing and pest management as integral to improving the health of the forests, and with the additional benefit of providing socio-economic outcomes for the region.

There was support for active management to be applied in the four priority state conservation areas. It was also suggested that where there are areas of less dense cypress pine, the forests should be managed to maintain or prevent further degradation of the existing environmental values.

While some stakeholders recognised that cypress pine is an invasive native species and supported intervention in dense stands, their support for the interventions were dependent on the nature, decision making and monitoring processes applied. It was suggested that if the recommendations were implemented, it would be beneficial to conduct rigorous scientific studies regarding:

- the environmental impact of a variety of ecological thinning methods
- the biodiversity supported by a range of forest stands at various densities
- the impact of soil properties on white cypress pine density.

Some stakeholders questioned whether the proposed management actions will maintain or improve environmental outcomes, as is required by the *National Parks and Wildlife Act 1974*. Others suggested that links between the proposed management interventions and key ecological values of the State Conservation Areas are not established.

Ecological thinning

Support for ecological thinning and suggestions for implementation

Many stakeholders promoted the need for ecological thinning of white cypress pine to improve the health of the forests and recognised that managed forests in this region have better ecological outcomes. They suggest that ecological and production outcomes are not mutually exclusive, and can contribute to the biodiversity and land management goals of the region. The stakeholders

supporting this view were predominately local community members, local and regional government organisations, and local industry and industry organisations.

Some submissions from local residents stated that the forests in the State Conservation Areas are not as healthy as they were in the past, and that the forests would benefit by removing dense vegetation (including black and white cypress pine, bulloak, acacia, box and wattle). Some included suggestions on how to improve or expand the report recommendations, for example:

- include other non-commercial invasive native species in active management
- use control sites within the State Conservation Areas to provide comparative measures over time
- retain the largest trees in order to naturally suppress younger white cypress pine regeneration
- incorporate old growth elements into ecological thinning tree selections, for example specific base retention levels for tree age classes
- conduct follow-up prescribed burning after ecological thinning - the sequencing of management actions is important to achieve the desired outcomes.

A number of stakeholders acknowledged that ecological thinning, burning and grazing play different and complimentary roles and that active management could not be successfully implemented via only one method. Some saw thinning as an initial solution for problems caused by the absence of burning or grazing and saw burning and grazing as more beneficial in the longer term management

Arguments against ecological thinning

Many stakeholders were completely opposed to ecological thinning as they believed that this would not achieve positive ecological outcomes. Thinning activities are seen to present significant risk to the environment and that the current management practices in the State Conservation Areas should not be altered. These stakeholders were predominately individuals, environmental organisations and environmental professionals.

Some of these stakeholders suggested that historical forest management practices in the Brigalow and Nandewar Community Conservation Areas had resulted in dense stands of white and black cypress pine (and bulloak), and had reduced the biodiversity in these areas. There is concern that applying similar practices again could give a similar effect.

A large number of submissions highlighted the compensation paid to restructure the region's timber industry as part of the NSW Government's 2005 Brigalow decision. They noted that logging and grazing activities had ceased when the forests were converted from state forests to state conservation areas. They viewed the draft recommendations as reopening the State Conservation Areas to these activities and felt that providing government funding to undertake these activities would in effect be subsiding the forestry industry twice.

Some stakeholders expressed concern about who would conduct the ecological thinning and the consequences of a breach of contract if a mistake was made by a contractor. There were also concerns about whether the National Parks and Wildlife Service would be able to resource the necessary audit and accountability mechanisms to manage these contracts.

It was felt by some stakeholders that commercial logging activities in non-conservation areas have historically been associated with negative impacts on threatened species and their habitats. They likened these activities to the proposed ecological thinning in the State Conservation Areas and raised concerns about the impact on biodiversity values, including:

- impacts on the threatened and endangered species listed in the Brigalow and Nandewar State Conservation Areas
- impacts such as erosion, soil compaction and the spread of weeds
- the spread of native grassland leading to an increase in fire risk.

Many stakeholders felt that dense stands of white cypress pine in the State Conservation Areas are a natural occurrence and should not be disturbed. There were concerns that ecological thinning is an unnatural disturbance that would impede on the development of these forests into mature ecosystems. Some suggested that the State Conservation Areas in the Brigalow and Nandewar region be upgraded to national park or nature reserve status to ensure their continual protection against resource exploitation.

Some stakeholders stated that dense stands of white cypress pine act as a carbon sink. There was concern that ecological thinning activities in these areas may reduce the capacity of carbon sequestration, which may contribute to climate change. It was also suggested that the carbon value of retaining woody thickening, such as white cypress pine, be explored under the Australian Government's Carbon Farming Initiative or other carbon markets as a way of ensuring profitable forests without commercial active management.

A number of the stakeholders that opposed ecological thinning were supportive of fire as a management tool.

Science behind recommendations

Some stakeholders suggested there is not enough scientific evidence to justify active management in the State Conservation Areas. There were concerns about a lack of scientific literature on ecological thinning as a management technique.

Some stakeholders felt that:

- scientific data on the environmental benefits arising from the proposed recommendations has not been sufficiently included in the report and should be further explored
- management actions should not commence until the results from the river red gum trial are finalised
- particular assumptions made in the report are unjustified, including:
    - the problem of dense white cypress pine and the need for active management, particularly in the lower density classes
    - the thinning of mature sawlog sized white cypress pine.

Many submissions referred to the Brigalow Belt South Bioregion as being one of Australian Government's 15 national biodiversity hotspots, and that it is therefore extremely important to get the undelaying scientific assumptions correct.

It was recommended that in order to justify active management, spatial data alone is insufficient and that further modelling and on-ground assessment and trials are required.

Requests for further information

A number of submissions suggested that further analysis is needed to distinguish between black and white cypress pine and bulloak. They recommended conducting spatial analysis and on-ground assessment to determine forest stand composition and densities. There were also some requests for further evidence and clarification on thresholds for management concern and their assumptions, such as density, patch size and threatened species exclusions.

Some stakeholders suggested it would be beneficial to investigate weed management strategies that may be required to manage the risks of weed invasion from the use of machinery in ecological thinning and from grazing.

One submission requested more information on whether eucalyptus species will regrow with the thinning of white cypress pine. It was suggested that before harvesting and burning, current eucalypt seed banks be investigated to ensure regeneration can occur.

A few stakeholders suggested that increased white cypress pine density results from poor soil fertility, where eucalypt regeneration is possible in degraded soils but results in the growth of stunted trees. They requested this issue be explored.

It was also suggested that the use of biological controls in the management of white cypress pine should be investigated as an alternative option to ecological thinning or grazing.

Grazing

Some submissions supported the use of an active management regime that includes grazing alongside ecological thinning and fire. Grazing was seen as an important part of the long-term management of white cypress pine forests. Stakeholders that predominately supported the use of grazing included local community members, local industry and industry organisations.

Some stakeholders provided recommendations to improve grazing as an active management tool, such as:

- include measures to monitor potential weed impacts
- include prevention measures to maintain appropriate ground cover
- grazing should not result in less than 15 centimetre sward height (5 centimetres was proposed in the report) with a minimum 70 percent ground cover west of Narrabri and in areas east of Narrabri 90 percent ground cover is recommended.

However, many other stakeholders were strongly opposed to grazing in the State Conservation Areas. They were concerned that grazing would cause ecological damage, particularly if using cattle. The specific concerns included:

- the risk of introducing and spreading weeds and pests
- erosion through the removal of ground cover and trail creation
- damage to vegetation and threatened species
- soil compaction.

The science used to justify grazing as an appropriate management intervention was seen as insufficient by some stakeholders. They did not believe targeted grazing reduces weeds and fuel loads, particularly in relation to conservation habitats. Some also questioned whether livestock would preferentially graze on native grasses as opposed to white cypress pine regrowth.

These stakeholders were also concerned that the reintroduction of grazing into the State Conservation Areas would require infrastructure development, for example, fencing and drinking troughs, of which the ecological and socio-economic impacts have not yet been investigated.

Some stakeholders noted that there is currently very little grass cover in the State Conservation Areas and questioned how grazing would be viable or useful.

Fire management

The majority of stakeholders supported the use of fire management; however, their views on how this would be best implemented varied significantly. Some were supportive of current practices continuing and others promoted taking different approaches in the future.

Many stakeholders saw fire management as a simple technique to manage dense white cypress regrowth. As controlled burning had the lowest cost per hectare of the management options presented in the report, it was seen as the most viable option for reducing fuel loads. There were requests for more information on prescribed burning as a management technique, in particular the most appropriate timing for prescribed burns.

Some supported the use of fire management to achieve a mosaic of fire-managed areas as the primary method for the control of white cypress pine regrowth. They suggested that the National Parks and Wildlife Service has not been resourced appropriately to achieve this previously and that further resources should be made available. It was put forward that with additional resources, results from fire management could be monitored and assessed to help evaluate the adaptive management plans.

Some felt that a mosaic of low intensity prescribed burns, after a period of high rainfall, should be applied as the primary management technique for white cypress pine regrowth. These stakeholders believe that low intensity burns can reduce fuel load, dispatch young white cypress pine, reduce the seed production of older pines, and allow for a diverse understorey.

However, other stakeholders thought that existing prescribed burning regimes had not achieved desirable environmental or socio-economic outcomes and therefore need to be reconsidered. They argued that fire management is currently undertaken at too low an intensity to actually reduce dense cypress. They specified that the use of fire as a management intervention should only be implemented after ecological thinning has been undertaken, as the current practice of low intensity fires does not result in a thinning effect.

Some also suggested that fire regimes in small fenced off areas are impractical and that the management of white cypress pine in this region would be better suited to ecological thinning for biochar. Others suggested that Aboriginal fire regimes, for example Aboriginal burning practices in the Firesticks program, should be used as a preferred management technique over thinning.

Cost recovery and commercial outcomes

Support for commercial outcomes

Cost recovery for active and adaptive management activities was supported by many stakeholders on the basis that government agencies have limited resources available and that cost recovery is therefore required to fund the proposed management activities.

They were also supportive of the employment opportunities created by active management, and that this would provide both positive ecological and commercial outcomes for the local community. This support was received from local community members, local industry and industry organisations. However, some of these stakeholders were concerned that the areas of white cypress pine forest that require thinning may have limited cost-recovery potential.

Some stakeholders supported commercial benefits but were concerned about these benefits being promoted to the community and raising expectations when they are not guaranteed. They suggested undertaking independent economic analysis to detail the benefits that may result from management actions.

Stakeholders suggested that a range of thinning by-products, for example, fertilizer and materials for use in the production of steel and metalwork, be considered to improve the viability of undertaking active management. It was also suggested that:

- multiple functions be performed at the same time to minimise costs, for example weed management
- the handling of large and small thinnings be coordinated to minimise transport costs
- value adding options for the thinning materials be investigated to maximise cost recovery.

It was suggested by some stakeholders that in order to address concerns about the potential for commercial drivers to influence ecological drivers, the plans of management for the State Conservation Areas should be specific about the following:

- locations of areas to be thinned
- planned thinning methods (manual, machinery etc.)
- time scale and thinning cycles.

Others suggested that a pragmatic approach would be to manage some parts of the State Conservation Areas for production values in order to pay for the management required to achieve ecological outcomes of other parts.

Arguments against commercial outcomes

Stakeholders that were against commercial outcomes from ecological thinning were primarily concerned that commercial drivers would influence what should be an ecologically based decision making process. They saw the proposed cost recovery practices as an attempt to extract profit from the National Park estate and instead felt that government should fund any management activities in the parks for the public good.

Some stakeholders were concerned that financial returns from thinning may not recover the full costs of management and therefore active management will be unviable for government. They believed this could create pressure to respond more to commercial drivers rather than ecological

decision making. They were also concerned that the financial returns may only provide very limited economic benefit to the region.

Some stakeholders were concerned that the other potential risks from ecological thinning, including injuries of workers, had not been considered.

It was also suggested that ecosystem services provided by the State Conservation Areas that are outlined in the report, be assigned economic value to protect them from ecological thinning.

More information required

A few stakeholders suggested that the amount of sawlog-sized thinning residues may have been overestimated, which may lead to unrealistic expectations of commercial gain from thinning activities. They suggested further on-ground surveys be conducted to help determine the quantity of available timber.

Some stakeholders questioned whether differences in tree height and their relative volumes had been economically assessed. They suggested further economic analysis to determine if thinning of smaller white cypress pine trees in the State Conservation Areas can support cost recovery.

It was also proposed by some stakeholders to conduct a review on infrastructure that provides access to these forests, for example machinery and transport, to determine any flow on costs to government.

One stakeholder identified tourism opportunities as alternative commercial opportunity in the State Conservation Areas and suggested they be explored.

Bioenergy

Support for the use of biomass for bioenergy

Many stakeholders supported the use of biomass for bioenergy as it may create an industry in the region that will support jobs and boost economic growth. Stakeholders recommended various options and products for a bioenergy industry. The suggested uses of thinning materials included:

- biochar for fertilisers
- charcoals for industry and metal smelting
- carbon water and air filtering products
- biochemicals and biofuels
- bioenergy as hot water, steam, syngas or electricity
- supply for bio-crude refineries for liquid fuel.

Some stakeholders thought that smaller biomass plants that produce heat and power would be favourably received by the local community. They recommended devolving an investigation into the potential uses of biomass to a cross-tenure management group to seek the best outcomes for the region.

Other stakeholders suggested it would be more ecologically viable to collect biomass to be converted to biochar. They recommended that biochar be returned to the soil to replenish nutrients and become a carbon store.

Arguments against the use of biomass

Some stakeholders did not support the use of biomass for bioenergy production. It was noted by some that there is no current bioenergy plant in operation in the region, and for one to be established it would require a reliable wood supply. This raised concerns that the need for biomass supply may compromise the management of the State Conservation Areas for ecological outcomes.

It was suggested that money invested in a bioenergy plant could be better spent on a solar plant, which would have lower running costs and would also be more sustainable due to the potential for biomass supply restrictions in the long-term.

Some stakeholders expressed concern about biomass from ecological thinning of native forest stands being used for bioenergy. They suggested that bioenergy production from the State Conservation Areas is non-renewable and believed it would have negative effects on carbon sequestration. They raised the following arguments against using biomass:

- ecological thinning of native forest for bioenergy production removes carbon sinks
- further carbon dioxide is released in the energy production process (for example, burning native forest for electricity generation can be as much as 6.4 times greater than the equivalent sized coal-fired power station)
- bioenergy production contributes to particulate pollution.

A few stakeholders stated that allowing NSW native forest vegetation to be burnt to generate electricity is unnecessary. They suggested bioenergy production from more sustainable biomass sources, such as agricultural waste, would be a better approach.

Firewood

Some stakeholders expressed support for firewood collection as a cost recovery technique for active management.

A few stakeholders referred to the river red gum ecological thinning trials, suggesting that timber available from active management in the NSW river red gum forests is not suitable or sustainable for firewood producers.

Governance

There was agreement between majority of stakeholders to merge the plans of management to create efficiencies when undertaking monitoring, evaluation and reporting activities. Some stakeholders expressed support for the governance arrangements in the State Conservation Areas being based on a whole of landscape cross-tenure approach.

There were suggestions on how to improve the governance recommendations, in particular:

- include local stakeholders, including those from the local timber industry as members of the Regional Advisory Council
- expand the Regional Advisory Council to include people with adaptive management expertise to help achieve triple bottom line outcomes
- create a commonality of intent between Zones 1, 2 and 3 of the Community Conservation Areas to achieve landscape wide outcomes.

Stakeholders proposed that either the National Parks and Wildlife Service or Forestry Corporation of NSW manage the operational components of the active management.

Some stakeholders expressed concern about the availability of evidence, and how the time periods for adaptive management and reporting to investors would function. They suggested including spatial data technologies in modelling the active and adaptive management plans to help reporting on the targets and outcomes of management interventions.

A few stakeholders also requested more detail on how the plans of management will be merged.

Some stakeholders did not support the use of a Regional Officers Working Group to develop and establish commercial opportunities to offset management costs. They saw the National Parks Regional Advisory Committee as the appropriate body to advise on the management of the State Conservation Areas and that further resources should be allocated to allow them to do so.

It was recommended by some stakeholders that Aboriginal communities should be more involved in all levels of the management process, in particular active management. They view further Aboriginal involvement is important to ensure ecological intentions are not passed over by economic drivers.

A few stakeholders suggested that aerial imagery data be shared between all land management groups in the area, including National Parks and Wildlife Service.

Legislative changes

Many stakeholders that were opposed to the report recommendations were opposed to any amendments to legislation because:

- legislation should not be amended as it has the potential to set a dangerous precedent of active management in other NSW protected areas
- significant time and resources has gone into protecting the State Conservation Areas through the *Brigalow and Nandewar Community Conservation Area Act 2005* and the Regulations
- the proposal to amend renewable energy legislation to allow burning of ecological thinning residues conflicts the intentions of the renewable energy legislation and regulations.

Questions were raised by some stakeholders about the compatibility of the recommendations with the objects of the *National Parks and Wildlife Act 1975* and with community expectations. These stakeholders suggested that the compatibility of the recommendations with existing legislation should be further explored in the final report.

Stakeholders that supported the report's recommendations did not object to legislative changes.

Other Issues

A number of stakeholders raised concerns about the availability of timber in State Forests (particularly larger logs) under the long-term wood supply agreement between Forestry Corporation of NSW and local timber businesses. One stakeholder proposed that conservation areas should be re-designated as State Forests. Recommendations about alternative tenure and wood supply agreements in State Forests are outside of the terms of reference for this report.

Attachment 7 - Summary of stakeholder engagement

Organisations consulted	
Government agencies / State owned corporations	
Department of Premier and Cabinet	NSW Rural Fire Service
Department of Primary Industries	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 and regional bodies	
Dubbo City Council	Regional Development Northern Inland
Gunnedah Shire Council	Regional Development Australia Orana
Narrabri Shire Council	Warrumbungle Shire Council
North West Local Land Services	
Environment groups	
Central West Environment Council	National Parks Association
Central West NRM Group	National Parks and Wildlife Advisory Council
Dubbo Field Naturalists	National Parks Northern Tablelands Regional Advisory Committee
Friends of the Pilliga	Northern Plains Regional Advisory Committee
Gilgandra Native Flora Society	Nature Conservation Council
Industry	
Andrews V & HD (Jack) Haulage Pty Ltd	NSW Apiarists' Association Inc.
Baradine & District Progress Association	NSW Farmers
Baradine Sawmilling Co	NSW Forests Products Association
Grants Sawmilling Co	Pilliga Natural Timbers
Gunnedah Timbers Pty Ltd	Renewed Carbon Pty Ltd
Hyde Haulage Pty Ltd	Universal Composts
Institute of Foresters of Australia NSW Division	
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 Area 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 the 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 the 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 the 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 the 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)	▪ The 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 plant and animal 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 the State Conservation Areas in the Brigalow Nandewar region. Activities in the State Conservation Areas need to be consistent with the objects of the Act and management principles for State Conservation Areas ▪ The 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 the 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 the State Conservation Areas ▪ The NSW Government is reviewing the *Native Vegetation Act 2003* (NSW) as part of the Biodiversity Legislation Review ▪ 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

Legislation	Brigalow Nandewar Community Conservation Area	Relevance to active management of cypress forests in the State Conservation Areas
		- trees cleared under an Integrated Forestry 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 the 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 ▪ The NSW Government is reviewing the *Threatened Species Conservation Act 1995* (NSW) as part of the Biodiversity Legislation Review

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 (percent)	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, Brigalow Belt South 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, Brigalow Belt South bioregion	94	✓	None	Pilliga East (0-10%)
467	Blue-leaved ironbark - black cypress pine shrubby sandstone open forest in the southern Brigalow Belt South 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%)
445	Brigalow viney scrub open forest on loamy soils in low hill landscapes in the northern Brigalow Belt South Bioregion NSW	20	-	Listed TSC Act (Endangered) Listed EPBC Act (Endangered)	Bingara (0-10%)

Veg ID No.	NSW Vegetation Classification and Assessment type	Extent remaining (percent)	Cypress pine type	Legal status	Mapped in State Conservation Areas
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, Brigalow Belt South 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, Brigalow Belt South 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 Brigalow Belt South 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 Brigalow Belt South 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 Brigalow Belt South Bioregion	80	✓	None	Goonoo (0-10%)
432	Dwyers red gum - dirty (Baradine) gum - cypress pine shrubby woodland of the Narrabri region of the Brigalow Belt South Bioregion	93	✓	None	Killarney (0-10%)
424	Dwyers red gum heathy low open woodland on sandstone ridges in the Pilliga Scrub, Brigalow Belt South Bioregion	100	-	None	Pilliga East (0-10%)
415	Fringe myrtle shrubland of the Pilliga Scrub	93	-	None	Pilliga (0-10%)

2 *Allocasuarina luehmannii* (commonly known as buloke, bull-oak or bulloak)

Veg ID No.	NSW Vegetation Classification and Assessment type	Extent remaining (percent)	Cypress pine type	Legal status	Mapped in State Conservation Areas
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 Brigalow Belt South 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 Brigalow Belt South and northern NSW South Western Slopes 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 National Park - Pilliga region in the Brigalow Belt South 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, Brigalow Belt South 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 Brigalow Belt South 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, Brigalow Belt South Bioregion	60	✓	None	Pilliga (0-10%)
468	Narrow-leaved ironbark - black cypress pine +/- Blakely's red gum shrubby open forest on sandstone low hills in the southern Brigalow Belt South Bioregion (including Goonoo)	67	✓	None	Beni (20-50%), Biddon (>50%), Goonoo (0-10%)

Veg ID No.	NSW Vegetation Classification and Assessment type	Extent remaining (percent)	Cypress pine type	Legal status	Mapped in State Conservation Areas
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, Brigalow Belt South 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 Brigalow Belt South 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, Brigalow Belt South 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 Brigalow Belt South - Sydney Basin Bioregions	60	✓	None	Durridgere (>50%), Goodiman (0-10%)
416	Pilliga "tank gilgai" wetland sedgeland rushland, Brigalow Belt South 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, Brigalow Belt South Bioregion	55	✓	None	Pilliga (0-10%), Pilliga West (20-50%)
511	Queensland bluegrass - redleg grass - rats tail grass - spear grass - panic grass derived grassland of the Nandewar and Brigalow Belt South Bioregions	10000	-	None	Bingara (0-10%), Leard (0-10%), Tingha Plateau (0-10%), Woodsreef (0-10%)

Veg ID No.	NSW Vegetation Classification and Assessment type	Extent remaining (percent)	Cypress pine type	Legal status	Mapped in State Conservation Areas
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 Brigalow Belt South 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, Brigalow Belt South 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 Brigalow Belt South 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 Brigalow Belt South 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 Brigalow Belt South and Upper Hunter regions	72	-	None	Durridgere (0-10%)
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%)

Veg ID No.	NSW Vegetation Classification and Assessment type	Extent remaining (percent)	Cypress pine type	Legal status	Mapped in State Conservation Areas
281	Rough-barked apple - red gum - yellow box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes and Brigalow Belt South 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 Brigalow Belt South 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, Brigalow Belt South 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, Brigalow Belt South 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%)
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%)

Veg ID No.	NSW Vegetation Classification and Assessment type	Extent remaining (percent)	Cypress pine type	Legal status	Mapped in State Conservation Areas
461	Tumbledown gum woodland on hills in the northern NSW South-western Slopes and southern Brigalow Belt South 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 Brigalow Belt South 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, Brigalow Belt South 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, Brigalow Belt South Bioregion	70	✓	None	Trinkey (10-20%)
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%)

Veg ID No.	NSW Vegetation Classification and Assessment type	Extent remaining (percent)	Cypress pine type	Legal status	Mapped in State Conservation Areas
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 Brigalow Belt South 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, Brigalow Belt South 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, Brigalow Belt South 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, Brigalow Belt South Bioregion	40	✓	Listed TSC Act (Endangered) Listed EPBC Act (Critically Endangered)	Pilliga East (0-10%)

✓ = vegetation group contains cypress pine
- = vegetation group does not contain cypress pine

TSC Act = Threatened Species Conservation Act 1995 (NSW)
EPBC Act = Environment Protection and Biodiversity Conservation Act 1999 (Cth)

Attachment 11 – Values currently supported by the Brigalow and Nandewar State Conservation Areas

Refugia and connectivity

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 1** 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, 2003).

Species, especially large and specialised mammals and birds, tend to be lost from small and isolated patches of native vegetation (Ford, Walters, Cooper, Debus, & Doerr, 2009; MacHunter, Wright, Loyn, & Rayment, 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 1** 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.

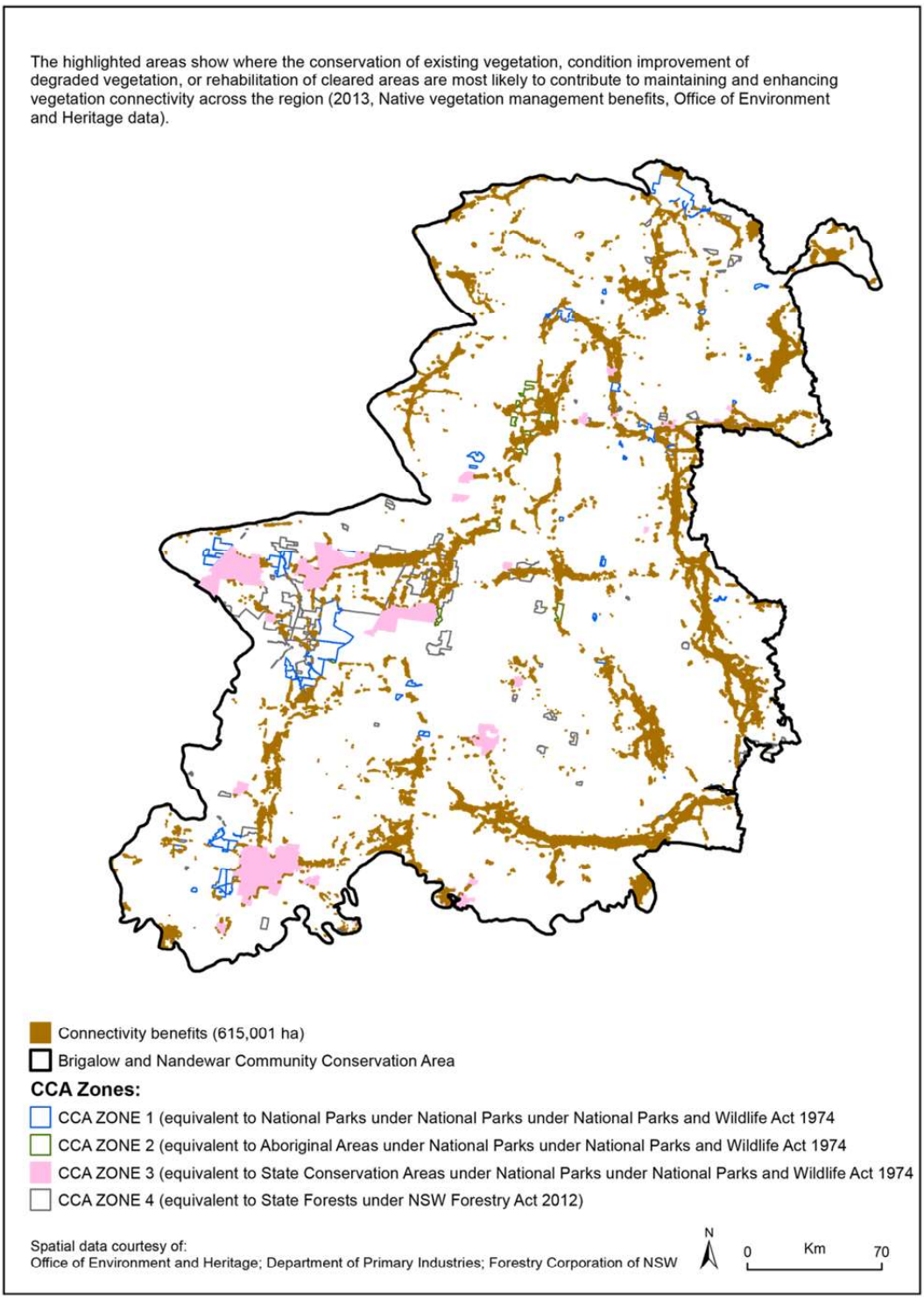

Figure 1: Indicative priority areas for achieving connectivity benefits in the Brigalow and Nandewar State Conservation Areas (after Drielsma et al., 2012)

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; EM Date, Ford, & Recher, 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 1** for examples). Typical canopy species include eucalypts[3], bloodwood[4], cypress[5] and bulloak[6] (J. T. Hunter, 2008a, 2008b, 2008c, 2010; Lindsay, 1967).

Table 1: Number of plant taxa, families and genera recorded in four State Conservation Areas

State Conservation Area	Number of vascular plant species[7]	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 cypress pine forest stands in State Conservation Areas[8] 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[9]; an average of 28.5 species per 20 x 20 metre plot (**Table 2**)
- 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 3).

3 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*).

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

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

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

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

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

9 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 2: 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[10]	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 3: 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%

10 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). 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 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 (J. T. 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 (EM Date, Goldney, Bauer, & Paull, 2000). Around 15 of the historically recorded species are extinct, such as the bridled nailtail wallaby (*Onychogalea fraenata*) and black-throated finch (*Poephila cincta*) (EM 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 (EM Date et al., 2000). Date & Paull (2000) recorded up to 63 species of reptiles in cypress and ironbark forests of the north-western slopes of NSW.

Other species, such as malleefowl (*Lepoia ocellata*), occur at the edge of their range in the region (Australian Government Department of the Environment, 2013b). 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, 2014a).

The Pilliga forests have been historically 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, Stanton, & Brassil, 2007). A recent survey in the Pilliga forests suggests the koala population has fallen significantly over the last 20 years (D. Paull, 2013). Survey sites were characterised by dead or dying vegetation, possibly due to water stress.

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) (D. C. 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 cypress pine seeds (Lacey, 1972)
- young healthy eucalypt regeneration (for koalas) (Kavanagh & Barrott, 2001).

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, 2013a).

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 12** 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 (EM Date et al., 2000).

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, 2013c). 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.).

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 2**).[11]

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 13)** (NSW Office of Environment and Heritage, 2013a). The highest number of sites 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:

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

- 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).

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 the 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 the Goonoo State Conservation Area (10), followed by the 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 13**.

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).

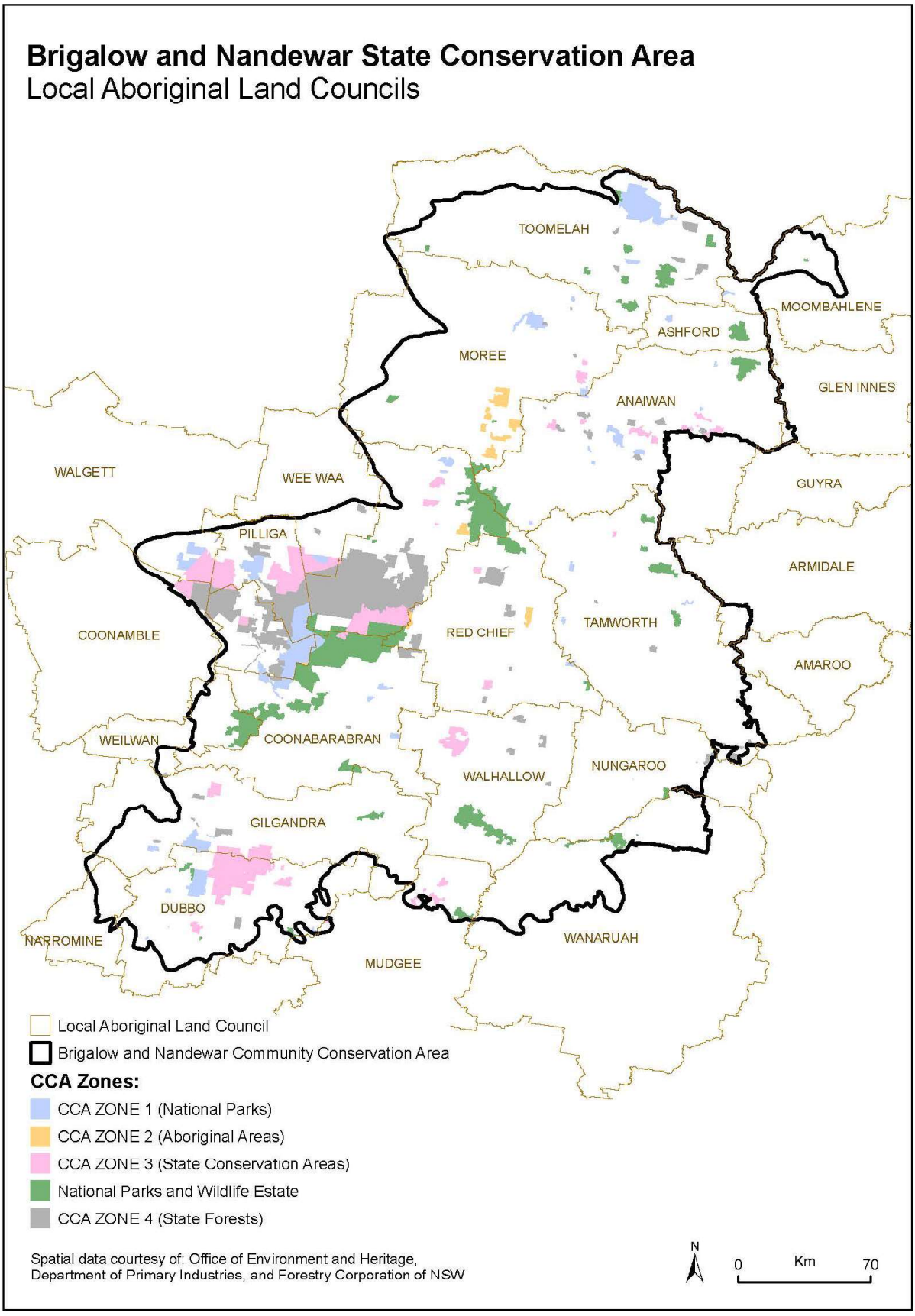

Figure 2: Map of Local Aboriginal Land Councils in the Brigalow and Nandewar region

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 14**).

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, 2011).

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, 2010). 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 did not receive 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 **Attachment 17**.

Other

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Attachment 12 - Threatened species

Threatened flora and fauna species in the Brigalow and Nandewar State Conservation Areas (NSW Office of Environment and Heritage, 2013b, 2014b).

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 13 – 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 14 - 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 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 area and national park (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[12]	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 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.

12 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.

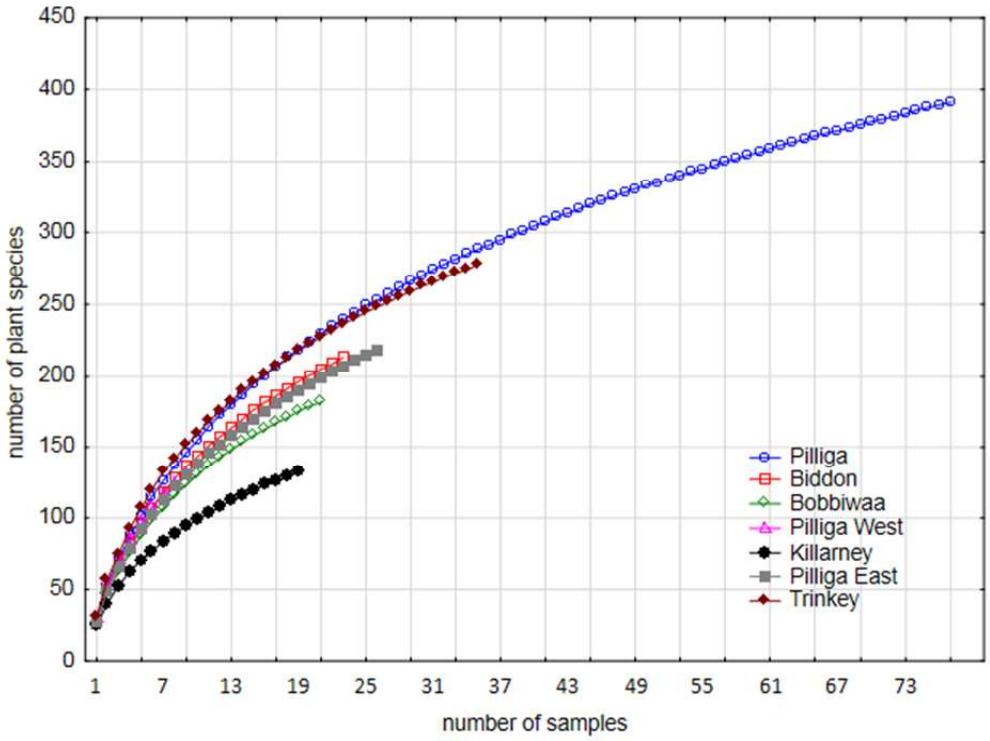


Figure A15.2: Plant species accumulation curves based on 20 x 20 metre survey samples for selected State Conservation Areas. Curves are averaged from multiple permutations of sample sequences

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* the State Conservation Areas. Measured as *dissimilarity* in plant species composition (the reciprocal of similarity), this difference in biodiversity between the State Conservation Areas averaged 86.6 meaning that, on average, the State Conservation Areas 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**).

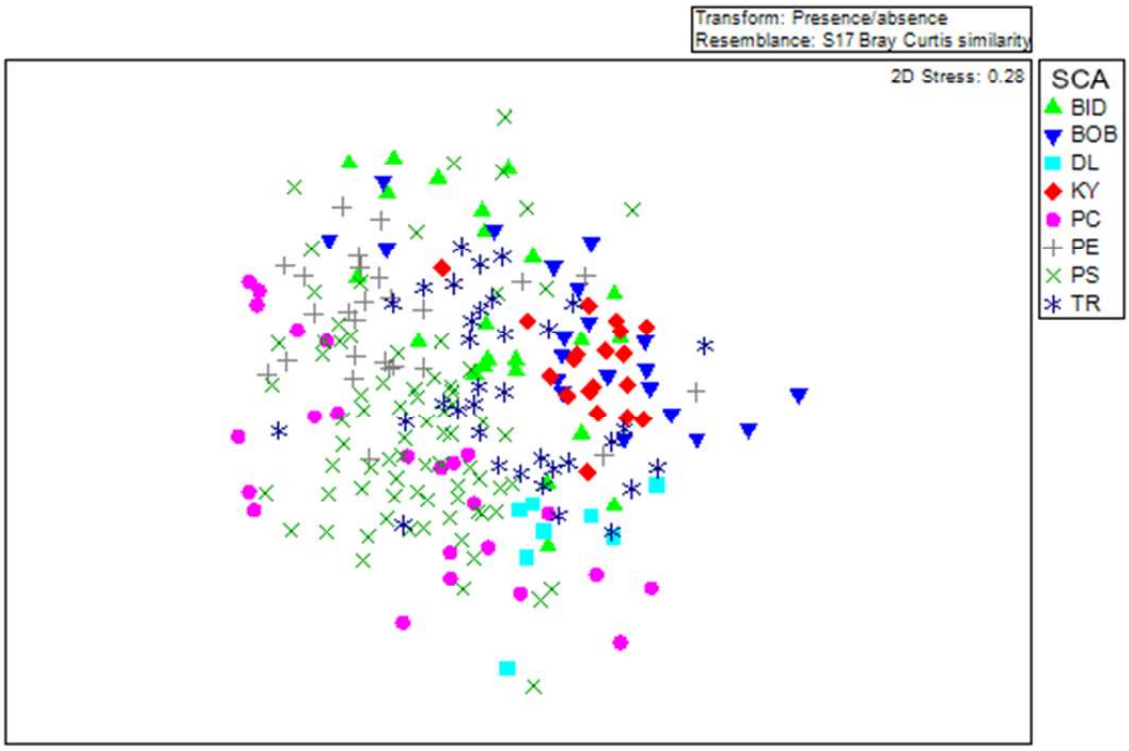


Figure A15.3: Multi-dimensional scaling (MDS) plot of plant species composition per sample (distance between points reflects relative difference in species composition) in Bidden (BID), Bobiwaa (BOB), Killarney (KY), Pilliga West (DL), Pilliga East (PE), Pilliga (PS), and Trinkey (TR) State Conservation 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 State Conservation Areas	State Conservation Areas contribution to observed plant species richness (percentage)
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%

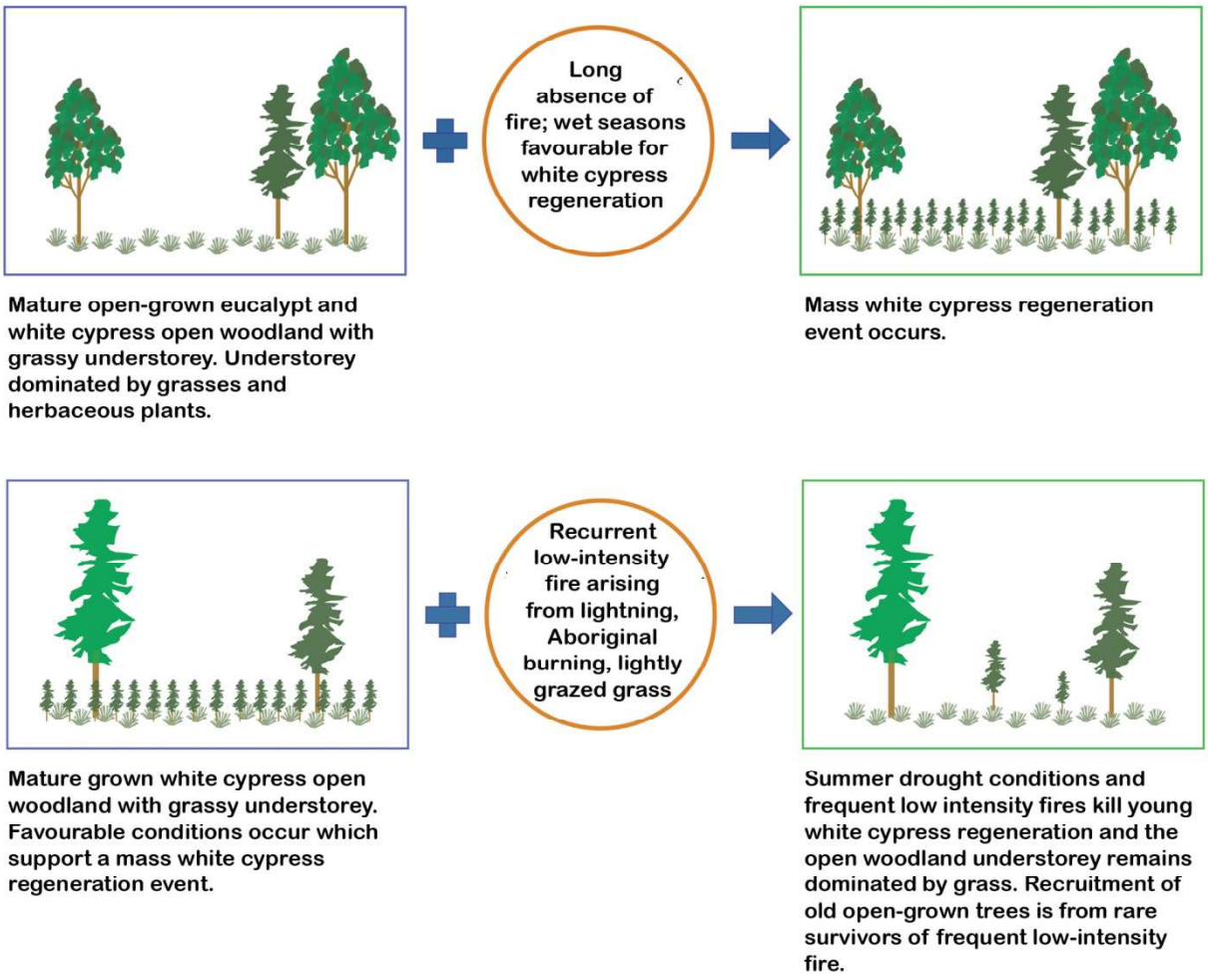
Overall, plant species similarity analyses within and between State Conservation Areas suggested that:

- 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.

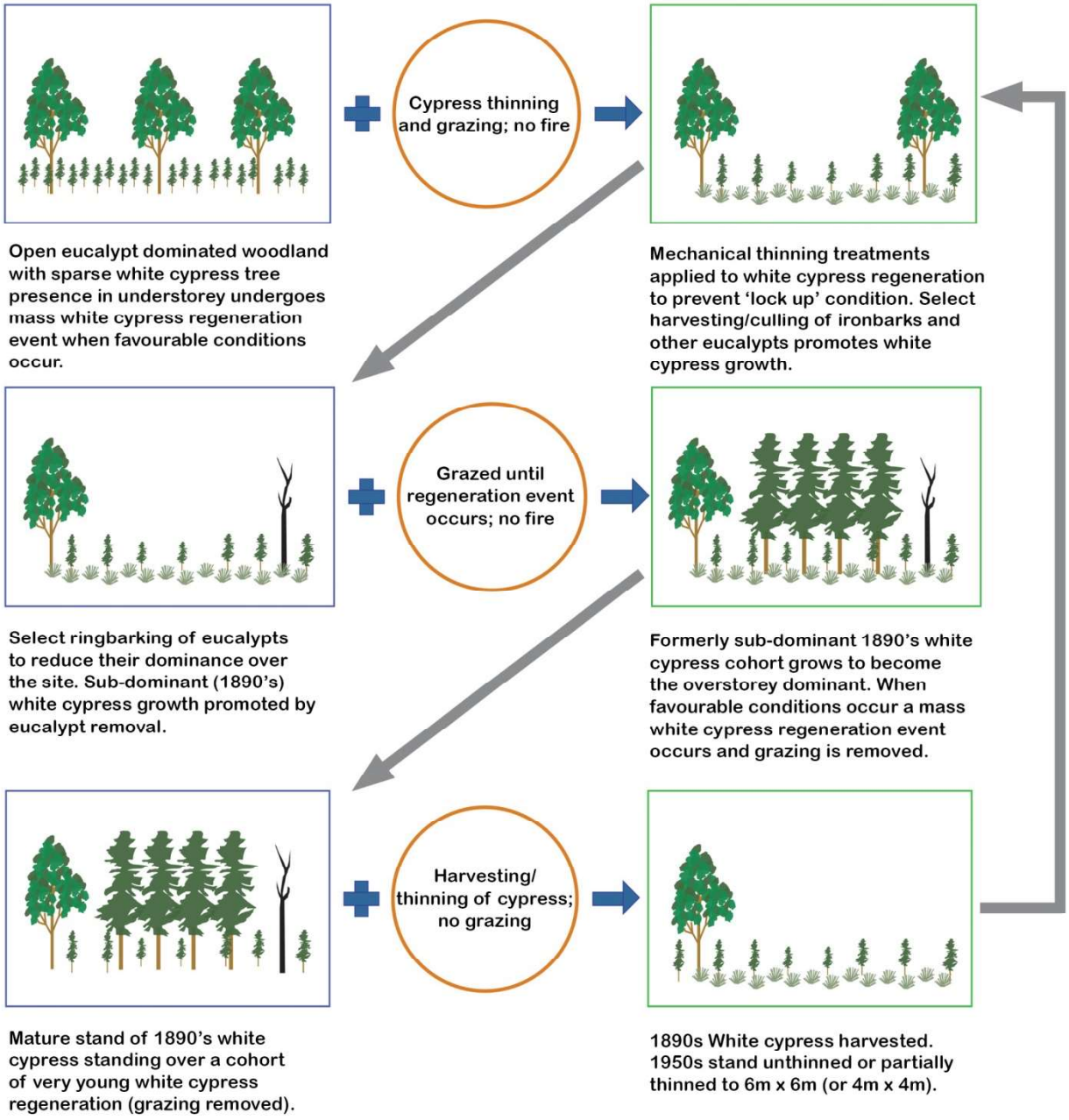
Attachment 16 – Generalised models of the likely structure and composition of Australian temperate woodlands in the Brigalow and Nandewar region

The NRC has developed generalised models of the likely structure and composition of Australian temperate woodlands in the Brigalow and Nandewar region both before (Model A) and after (Model B) European settlement.

These models focus on white cypress pine given the available research and information on this species. The intent of the models is to illustrate widespread, commonly encountered changes and functions, and do not represent any specific State Conservation Areas. Individual reserves have experienced different disturbance regimes and consequent impacts.



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



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

Attachment 17 - 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.[13] ▪ 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.

[13] Exact dates of wildfire events in the 1890s are unknown due to lack of historical data (Whipp et al. 2009).

Date	Event
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 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.

Date	Event
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 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.

Date	Event
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). 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 18 – Management priorities for pest animals and weeds

Management priorities for pest animals and weeds in State Conservation Areas

State Conservation Area	Target pests or weeds	Management priority	Cypress communities at risk
All	Wild dog	Critical – economic	No
Adelyne	St Johns wort, African boxthorn, prickly pear, wandering jew	Lower – previous programs	No
Beni	African boxthorn, mother-of-millions, Paterson's curse, Bathurst burr, prickly pear	Lower – previous programs	No
Biddon	Fox	Lower – previous programs	No
	Prickly pear, blue heliotrope	Lower – previous programs	No
Bingara	Blackberry, St John's wort , Coolatai grass blue heliotrope, African boxthorn, mother of millions, prickly pear	Critical – threatened species conservation	No
	Feral goat, feral pig	Critical – threatened species conservation	No
Bobbiwaa	Mother-of-millions, prickly pear, Bathurst burr, Noogoora burr	Critical – threatened species conservation	No
	Feral pig	Critical – threatened species conservation	No
	Fox	Lower – previous programs	No
Bullawa Creek	Mother-of-millions, prickly pear	Lower – previous programs	No
Cobbora	Fox	Critical – threatened species conservation	No
	African boxthorn, spiny burrgrass, prickly pear	Lower – previous programs	No
Durridgere	Wild dog, fox	Critical – economic	No
	Pig, goat, deer	Medium – cooperative program	No
	Rabbit	Lower – localised program	No
	Prickly pear, blackberry, thistles, Paterson's curse, St John's Wort	Lower – previous programs	No
Goodiman	Fox	Medium – cooperative program	No

State Conservation Area	Target pests or weeds	Management priority	Cypress communities at risk
Goonoo	Fox	Critical – threatened species conservation	No
	Blue heliotrope, prickly pear, Paterson's curse, Bathurst burr, Noogoora burr	Lower – localised programs	No
	Prickly pear	Lower – previous programs	No
	Rabbit	Lower – previous programs	No
Goonoowigal	Feral pig, feral goat	Critical – threatened species conservation	**Yes**
	Tree of heaven, Coolatai grass, mother of millions, St Johns wort, blackberry, privet, cats claw creeper	Critical – threatened species conservation	**Yes**
Gwydir River	Blackberry, blue heliotrope, box thorn Coolatai grass, *Salix* spp., tree of heaven, *Xanthium* spp.	Critical – threatened species conservation	No
	Feral goat, feral pigs, deer, rabbit	Critical – threatened species conservation	No
Killarney	African boxthorn, prickly pear	Lower – previous programs	No
	Fox	Lower – previous programs	No
Leard	Feral pig	Lower – previous programs	No
	African boxthorn, prickly pear	Lower – previous programs	No
Merriwindi	Tiger Pear, spiny burrgrass	Critical – threatened species conservation	No
Pilliga	Tiger pear, prickly pear	Critical – threatened species conservation	No
	Feral Pig, fox	Medium – cooperative program	No
Pilliga East	Fox	Medium – cooperative program	No
	Blue heliotrope, spiny burrgrass, thistles, prickly pear	Lower – previous programs	No
	Rabbit	Lower – previous programs	No
Pilliga West	African boxthorn, tiger pear	Critical – threatened species conservation	No
	Feral pig	Medium – cooperative program	No

State Conservation Area	Target pests or weeds	Management priority	Cypress communities at risk
	African boxthorn, prickly pear, Mother-of-millions, tiger pear, tree pear, prickly pear	Lower – previous programs	No
Tingha Plateau	Feral cat	Critical – threatened species conservation	No
	Coolatai grass, whisky grass	Medium – cooperative program	**Yes**
	Feral pig, feral goat	Lower - localised program	**Yes**
Trinkey	Feral pig	Medium – cooperative program	No
	Fox	Lower – previous programs	No
	Mother-of-millions, tiger pear, prickly pear	Lower – previous programs	No
Warialda	Box thorn, Coolatai grass, prickly pear spp.	Medium – cooperative program	No
	Feral pig, feral goat, fox, feral cat	Medium – cooperative program	No
Wondoba	Fox	Lower – previous programs	No
	Prickly pear	Lower – previous programs	No
Woodsreef	Boxthorn, Coolatai grass, prickly pear spp., St. John's wort	Medium – cooperative program	No
	Feral pig, feral goat, fox, feral cat	Medium – cooperative program	No

Sources:

- NSW Office of Environment and Heritage. (2012a). Regional Pest Management Strategy 2012-17: Blue Mountains 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. (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. (2012c). Regional Pest Management Strategy 2012-17: Northern Tablelands Region – a new approach for reducing impacts on native species and park neighbours. Sydney: NSW Office of Environment and Heritage.

Attachment 19 – 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 untreated non-durable species 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 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[14]

Product	Size	Delivered buying price (free in store) ($ per cubic metre)	Retail 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 **Table 28**, **Section 9.3.1**.

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

14 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[15]

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

15 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[16])
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.

16 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.

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 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 in these state forests.[17]

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 recovery opportunities for an active management program in the State Conservation Areas. Hardwoods are currently the preferred firewood species, and targeted marketing and promotion would be required to make bulloak a viable alternative to ironbark.

17 *Eucalyptus paniculata, Eucalyptus siderophloia, Eucalyptus sideroxylon* and *Eucalyptus crebra.*