Evaluation of biodiversity values and impacts of Aleppo Pines in the lower Field River

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T&M Ecologists

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Certain assumptions have been made in the preparation of this report. We have assumed that all information and documents provided to us by the Client or as a result of a specific request or enquiry were complete, accurate and up-to-date. Where we have obtained information from a government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware of any reason why any of the assumptions are incorrect.

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Executive summary

This report provides an assessment of the positive and negative values that Aleppo Pines provide to local ecosystems in Cormorant Drive Reserve at the terminus of the Field River, with a particular focus upon the Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus whitei*).

The Aleppo Pine (**Pinus halepensis*) was introduced to Australia in the 19th century and has been widely planted since at least the 1920s. The species has the ability to form dense monocultures and out-compete native woodland areas. It has been introduced throughout the world and is considered as one of the most invasive pines. In the Mount Lofty Ranges, feral populations are spreading with significant infestations on Brown Hill Creek, Cudlee Creek, Black Hill and Norton Summit, and infestations have developed on the Fleurieu Peninsula at Sellicks Hill, Rapid Bay, Normanville, the Willunga Basin and Onkaparinga Estuary. The species is declared under the *Landscape South Australia Act 2019*.

The two dense stands of Aleppo Pines in Cormorant Drive Reserve are providing a food resource for the State Vulnerable Yellow-tailed Black Cockatoo, and also shelter and perching habitat for other bird species, including the regionally Vulnerable Nankeen Night Heron (*Nycticorax caledonicus*). However, the Pines are having a negative impact on local ecosystems in a number of ways. The heavy cover of pines is shading out other plant species and preventing regeneration. The heavy layer of needles is modifying soil conditions, and preventing establishment of native seedlings. The dense cover and poor ground layer is restricting basking opportunities for reptiles, and the depauperate understorey would provide little feeding habitat for birds. The pines would also be dropping significant quantities of needles into the Field River, and likely impacting water quality. The presence of pines is also precluding native plant species that could provide useful resources for native fauna, such as nectar and fruit/berry resources. Their seed, spread by the wind, is likely to blow some distance and cause seedling pines to emerge in other areas, including in other sections of the Cormorant Drive Reserve.

An arborist has prepared a staged proposal for removal of the Aleppo Pines across a six year timeframe, based upon the condition, size and amenity value of each tree, with the largest trees in best condition and with high amenity value left until the final year for removal. This staged plan for removal is considered unlikely to have an overall impact on the Yellow-tailed Black Cockatoo population in the Mount Lofty Ranges. The presence of a substantial quantity of old cones on the pines (ie uneaten by Yellow-tailed Black Cockatoos) indicate that, across the longer term, these particular pines do not form a critical resource for the Cockatoos. The presence of a nearby stand of Aleppo Pines mean that Yellow-tailed Black Cockatoos are still likely to feed in the local area, even in the absence of the Cormorant Drive trees.

The six year planned removal is considered to be a sensible and logical approach to removal of Aleppo Pines in Cormorant Drive Reserve. The staged and targeted removal of trees in poor health or poor form is removing the trees likely to be of least value for Yellow-tailed Black Cockatoos first. This approach also provides an opportunity to review at various stages of the project, with the largest trees in best condition left until year 6 of the removal program. The approach taken to removal thus ensures the trees most likely to provide the greatest resources are not removed until last. If any new information should emerge regarding the importance of this stand of Aleppo Pines to Yellow-tailed Black Cockatoos (as it relates to the survival of the species), consideration could be given to retention of a small number of trees.

A revegetation plan, following pine removal, is included in this report. It should be noted that revegetation in the site is unlikely to provide the same level of food resources, even if known food native plants are utilised (such as Hakeas and Allocasuarinas), due to both a lower seed output by these native plants compared to Aleppo Pines, as well as the likelihood that the Cockatoos will preferentially seek out Aleppo Pines over these native species. Notwithstanding this, some of the species present in the Reserve and in the revegetation proposed could potentially provide seed resources if Aleppo Pine seed was in short supply. The six year plan for removal provides opportunities for existing revegetation, along with a concurrent program of revegetation,

to provide habitat values for a broader suite of species than are currently provided by the dense stand of pines.

Overall it is recommended that the six year plan for removal of the Aleppo Pines is followed, provided that suitable concurrent revegetation programs are undertaken. It is also recommended that an ecologist re-evaluate the site after three years, and provide an up-to-date review of the effectiveness of the Aleppo Pine removal, an evaluation of the revegetation being undertaken and an update of any current research as it relates to Aleppo Pines and importance to Yellow-tailed Black Cockatoos.

1. Introduction

The Lower Field River catchment contains approximately 30 mature Aleppo Pine trees. Recently these pines have become of high interest to the local community and the City of Marion Council. Over the past 10 years a number of reports have been written on the Aleppo Pines, and their impact on flora and fauna in the region.

At the General Council Meeting on 29 July 2020 Council adopted the motion that staff will engage an independent expert to prepare a comprehensive assessment of the staged removal of the Aleppo Pines and the ecological changes on the local ecosystem. This report provides that assessment, with a focus on the positive and negative values that Aleppo Pines provide to local ecosystems. It also provides a particular focus upon the Yellow-tailed Black Cockatoo, as this State Vulnerable species is known to feed extensively on the seed of Aleppo Pines. This assessment is based upon a comprehensive literature review, and site inspections of the area in question.

2. Review of literature on distribution, invasiveness and habitat values provided by Aleppo Pines (**Pinus halepensis*)

The Aleppo Pine (**Pinus halepensis*) is a large (25-30 metre) coniferous species from the Mediterranean. Its natural distribution extends from Morocco in the west to Jordan in the east, and from France in the north to Palestine in the south. It is an introduced species in South Australia.

History

The Aleppo Pine was introduced to Australia in the 19th century and has been widely planted since at least the 1920s. It was recommended as a windbreak and shelter tree in regions with 450 to 760 mm winter-maximum rainfall. In some country towns it has been used to form avenues that have a high amenity value. However, its useful life is in the order of decades rather than centuries, and many of these plantings are now being replaced as trees die or become a hazard due to falling branches[1].

Description

Aleppo Pine is a medium to large tree, ranging from 5-20 metres tall. The trunk often divides half way up into 2 or more stems[2]. It has deeply fissured reddish brown bark[3]. It has needle like leaves which are arranged in groups of two enclosed in a light brown or greyish sheath at the base. The leaves are 7 to 12 mm long and often have a twist. This species produces male and female cones on the same tree. The female cone is brown and oval shaped between 6 and 12 cm long and 4 to 7 cm wide. The cylindrical males are smaller and clustered at the branch tips. The female cones bend back (deflect) on the branch and remain on the tree after the seeds have matured. It takes 2 to 3 years for the seeds to mature[4]. It is a serotinous species, ie mature seeds are

[1] Government of South Australia (undated). Declared Plant Policy under the Natural Resources Management Act 2004. Aleppo Pine (*Pinus halepensis*).
[2] https://profiles.ala.org.au/opus/weeds-australia/profile/Pinus%20halepensis accessed 4/9/20.
[3] Prescott, A. (2012). It's Blue with Five Petals. Hyde Park Press, Adelaide.
[4] https://profiles.ala.org.au/opus/weeds-australia/profile/Pinus%20halepensis accessed 4/9/20.

retained in persistent cones, and their release is often delayed, building up a canopy-stored seed bank[5]. The seed is then dispersed by wind, or can be dispersed by birds, particularly the Yellow-tailed Black Cockatoo[6]. Cone production begins at approximately 4 years, and mature trees may produce many thousands of seeds in higher rainfall conditions[7].

Invasiveness of species

The Aleppo Pine was introduced by settlers for windbreaks and as amenity plantings, and is now widespread in cultivation across South Australia[8]. The species has the ability to form dense monocultures and out-compete native woodland areas[9]. It has been introduced throughout the world and is considered as one of the most invasive pines. In the Mount Lofty Ranges, feral populations are spreading with significant infestations on Brown Hill Creek, Cudlee Creek, Black Hill and Norton Summit, and infestations have developed on the Fleurieu Peninsula at Sellicks Hill, Rapid Bay, Normanville, the Willunga Basin and Onkaparinga Estuary[10]. The species is declared under the *Landscape South Australia Act 2019* under provisions 186(2), 188(1) for the whole of the state, and 192(2) and 194 for the Eyre Peninsula, Green Adelaide, Hills and Fleurieu, Kangaroo Island, Northern and Yorke, Murraylands and Riverland, and Limestone Coast Regions.

The provisions that apply to the Cormorant Drive Reserve area are therefore:

- 186(2): a person must not transport or move, or cause or permit to be transported or moved, on a public road within a declared area for a class of animals or plants to which this subsection applies—
  (a) an animal or plant of that class; or
  (b) any animal, plant, soil, vehicle, farming implement or other produce, goods, material or thing carrying an animal or plant of that class.
- 188(1): Subject to this Act, a person must not sell an animal or plant of a class to which this subsection applies.
- 192(2): Subject to this section, an owner of land within a declared area for a class of animals or plants to which this subsection applies must control and keep controlled all animals or plants of that class on that land.
- Boards may recover certain costs from owners of land adjoining road reserves

The *Landscapes South Australia Act 2019* defines control in relation to a particular class of plants, as any of the following:

(i) destroy the plants;
(ii) reduce and inhibit the propagation of the plants;
(iii) prevent the spread of the plants;
(iv) undertake any other prescribed action,

as far as is reasonably achievable.

The Landscapes South Australia Act 2019 therefore, as far as is reasonably achievable, obligates the City of Marion to undertake at least one of the actions (i) to (iv) above. It should be noted that this is different to provision 186(1) of the Act, which obligates landholders to destroy all animals or plants of that class on their land.

[5] Nathan, R., Safriel, U.N., Noy-Meir, I. and Schiller, G. (2001). Seed release without fire in *Pinus halepensis*, a Mediterranean serotinous wind-dispersed tree. Journal of Ecology 87(4) 659-669.
[6] Muyt, A. (2001). Bush Invaders of South-East Australia. McPherson's Printing Group, Victoria.
[7] Government of South Australia (undated). Declared Plant Policy under the Natural Resources Management Act 2004. Aleppo Pine (*Pinus halepensis*).
[8] Government of South Australia (undated). Declared Plant Policy under the Natural Resources Management Act 2004: Aleppo Pine *Pinus halepensis*.
[9] Virtue JG, Melland RL. 2003. The environmental weed risk of revegetation and forestry plants. DWLBC 2003/02.
[10] https://landscape.sa.gov.au/hf/plants-and-animals/pest-plants-and-animals/pest-plants/aleppo-pine-fact accessed 4/9/20.

Impact on ecosystems

Aleppo Pine stands radically simplify the composition of ground-flora vegetation, shade or crowd out most overstorey species and prevent almost all regeneration[11]. Stands reduce the fertility of soils, alter nutrient and water cycles, dramatically reduce light levels and generate thick leaf litter that prevents seedling establishment by most indigenous species. The oil from fallen needles has also been noted to suppress the growth of native plants[12], and has herbicidal properties[13]. The total annual mass of litter produced by Aleppo Pines ranges from 150 to 530 g m^2 [14]. In a mediterranean climate (such as Adelaide's), there is a very slow decomposition rate of the sclerophyllous material in the thick leaf litter this produces. As such, the leaf litter tends to form a dense mat of needles. The thick pine leaf litter can reduce the fertility and change nutrient cycling in soils as well as changing the water cycle[15]. The pines also present a fire hazard, with flammable cones and dead lower branches often retained on the trees for many years[16].

Water use

There have been several studies on the impact of Aleppo Pines on the recharge of groundwater systems on southern Eyre Peninsula. It has been concluded that Aleppo Pines can have a substantial impact on the sustainability of groundwater recharge processes[17]. However, it was also noted that native species, such as *Eucalyptus camaldulensis var. camaldulensis*, may have a similar effect on groundwater systems[18].

Habitat values

Aleppo Pine stands provide very little in the way of food or shelter for most native fauna [19], as they lack hollows and flowers, have a very dense structure and poor ground layer. The dense cover that provides little light would likely be unfavourable for ectothermic species such as reptiles. Reptile species richness, abundance and diversity have been demonstrated to decrease as a result of pine invasion in South African shrublands[20]. Dense weed canopy cover has been demonstrated to decrease reptile abundance[21], and removal of dense canopy has resulted in an increase in reptile species richness and abundance[22].

Shading, Ben-david at al[23] , noted increased songbird nest depredation as a result of Aleppo Pine encroachment in Mediterranean shrubland. In a recent discussion of the subject at a general meeting of Birds SA, a member noted "that a pine plantation is a better alternative to native bush than a bare paddock, and that native scrub adjacent to pines can carry a significant number of small birds, despite the pines forming a monoculture."[24]. Species such as the Australian Kestrel (*Falco cenchroides*), Nankeen Night Heron (*Nycticorax caledonicus*) and Brown Goshawk (*Accipiter fasciatus*) have been observed roosting and consuming prey in

[11] Muyt, A. (2001). Bush Invaders of South-East Australia. McPherson's Printing Group, Victoria.
[12] https://landscape.sa.gov.au/hf/plants-and-animals/pest-plants-and-animals/pest-plants/aleppo-pine-fact accessed 4/9/20
[13] Amri, I., Hamrouni, L., Hanana, H., Gargouri, S., Fezzani, T. and Jamoussi, B. (2013). Chemical composition, physico-chemical properties, antifungal and herbicidal activities of *Pinus halepensis* Miller essential oils, Biological Agriculture & Horticulture, 29:2, 91-106,
[14] Litter Production and Decomposition in Pinus halepensis forests. Ecology, Biogeography and Management of Pinus halepensis andP brutia Forest Ecosystems in the Mediterranean Basin, pp. 183-190. Backhuys Publishers, Leiden, The Netherlands
[15] https://profiles.ala.org.au/opus/weeds-australia/profile/Pinus%20halepensis accessed 4/9/20.
[16] Government of South Australia (undated). Declared Plant Policy under the Natural Resources Management Act 2004. Aleppo Pine (*Pinus halepensis*).
[17] Swaffer et al., (under review). Applying Satellite-Derived Evapotranspiration Rates to Estimate the Impact of Vegetation on Regional Groundwater Flux.
[18] Swaffer, B (2014). Trees and groundwater on the water-limited Eyre Peninsula: an ecohydrological perspective. PhD thesis, Flinders University, Adelaide.
[19] Muyt, A. (2001). Bush Invaders of South-East Australia. McPherson's Printing Group, Victoria.
[20] Schreuder, E. and Clusella-Trullas, S. (2016). Exotic trees modify the thermal landscape and food resources for lizard communities. Oecologia 182, 1213–1225
[21] Martin, L.J. (2013). Impacts of invasive exotic plants on reptile and amphibian assemblages. Honours thesues, University of Technology, Sydney.
[22] Pike, D.A., Webb, J.K. and Shine, R. (2011). Removing forest canopy cover restores a reptile assemblage. Ecological Applications 21(1): 274-280.
[23] Ben-David, A., Shamon, H., Izhaki, I. et al. Increased songbird nest depredation due to Aleppo pine (*Pinus halepensis*) encroachment in Mediterranean shrubland. BMC Ecol 19, 52 (2019).
[24] The Birder Winter 2020 254 page 14

Aleppo Pines[25]. The dense cover provided by pines would provide perching sites and cover for smaller bird species, although the depauperate understorey would provide few opportunities for feeding. Gepp (1986)[26] noted that of 66 species of birds he considered to use woodland and open woodland habitats in the Mount Lofty Ranges, 31 would use mature *Pinus radiata* plantations. Of these 31 species, fourteen may use pines for nesting. This indicates that pines can provide shelter and nesting habitat for some birds, but that this would only be for a limited array of species than a more natural woodland habitat.

The principal value provided for fauna is through the seeds of Aleppo Pines, which are extracted from the cones by a number of species, which locally includes the Sulphur-crested Cockatoo (*Cacatua galerita*), the Little Corella (*Cacatura sanguinea*) and the Australian Magpie (*Cracticus tibicen*))[27]. It should be noted that the Little Corella and Sulphur-crested Cockatoo (unlike Yellow-tailed Black Cockatoos) are noisy and have the potential to damage nearby property[28], and are a management issue in some Adelaide Hills towns.

3. Review of current distribution, ecology and conservation status of the Yellow-tailed Black Cockatoo

The Yellow-tailed Black Cockatoo is a large (56-66cm) black parrot with a long tail, broad wings and strong bill. It can be easily distinguished by the yellow panels in its tail and yellow ear coverts[29]. The Yellow-tailed Black cockatoo is found from Queensland, down the east coast and across to South Australia. There are currently three recognised subspecies for the Yellow-tailed Black-Cockatoo, these being *C. f. funereus* that is found through south-east Queensland, eastern New South Wales and eastern Victoria, *C. f. xanthanotus* that occurs in Tasmania and the islands of Bass Straight, and *C. funereus whitei* that occurs in western Victoria, and southern South Australia[30].

The species feeds on seeds, nuts, fruit or berries from a wide range of native trees and shrubs such as eucalypts, banksias, acacias and hakea. They also feed on a large range of insects and larvae[31]. The species is capable of adapting to the changed conditions by supplementing its diet with seeds and nuts of introduced flora such as pines. The natural habitat they prefer ranges from coastal heath, woodland and forest but they are increasingly to be found in pine plantations and patches of pine trees in urban and rural areas[32].

Breeding occurs from October to March in South Australia. The nest is a large tree-hollow lined with a bed of woodchips. Two eggs are laid and incubated by the female only. The male feeds the female at or near the nest hollow several times a day during incubation by regurgitating food for her. He will also roost either in the nest tree or in an adjacent tree. Whilst incubating, the female only leaves the nest briefly to drink and receive food from her mate[33]. Usually only one chick survives which fledges after 28-29 days and remains with the parents until the next breeding season[34]. The main nesting trees are large stringybarks and Candlebarks (*Eucalyptus dalrympleana*) in the central Mount Lofty Ranges, plus large stringybarks at sites from Mount Bold to Deep

[25] Way, S (2006) Strategic management of Aleppo Pines on Lower Eyre Peninsula to maximise biodiversity conservation outcomes, Department for Environment and Heritage, South Australia.
[26] Gepp, B.C. (1986). Birds. In The Ecology of the Forests and Woodlands of South Australia pages 75-84. Government Printer, South Australia.
[27] Paton, P. (2016). A second observation of an Australian Magpie feeding on pine seeds. December 2016.
[28] Chris Daniels, pers. comm.
[29] Way, S. L. and van Weenen, J. (2008) Eyre Peninsula Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus whitei*) Regional Recovery Plan. Department for Environment and Heritage, South Australia.'
[30] Way, S. L. and van Weenen, J. (2008) Eyre Peninsula Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus whitei*) Regional Recovery Plan. Department for Environment and Heritage, South Australia.'
[31] Fox, J. and Brereton, R. (2004). Yellow-tailed black cockatoo (*Calyptorhynchus funereus*). In Linking landscape ecology and management to population viability analysis. A project by the University of Melbourne prepared for Forestry Tasmania.
[32] https://birdssa.asn.au/birddirectory/yellow-tailed-black-cockatoo/ accessed 9/9/2020
[33] Way, S. L. and van Weenen, J. (2008) Eyre Peninsula Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus whitei*) Regional Recovery Plan. Department for Environment and Heritage, South Australia.'
[34] https://birdssa.asn.au/birddirectory/yellow-tailed-black-cockatoo/ accessed 9/9/2020

Creek Conservation Park[35]. A lack of large tree hollows required for nesting is considered to be one of the key limiting factors in population size[34]. When breeding, the activity of pairs is likely to be concentrated within 10 kms of nest locations, as has been shown for similar species of Black-Cockatoo[36].

Conservation Status of the species

The Yellow-tailed Black Cockatoo is not listed under the *Environment Protection and Biodiversity Conservation Act 1999* (ie is not considered to be nationally threatened), but is listed as Vulnerable under the *National Parks and Wildlife Act 1972*, and is considered Vulnerable for the Adelaide and Mount Lofty Ranges region[37]. No regional trend was assigned to the species due to a lack of suitable time-series data[38]. In a May 2011 survey, the population in the Mount Lofty Ranges was estimated at 2,029, and this is considered the upper estimate of the population size within the region[39]. The population of Yellow-tailed black Cockatoos ranges over a large proportion of the Adelaide and Mount Lofty Ranges region and immediate surrounds throughout the year. They are particularly widely distributed during the breeding season (from late spring through to the start of autumn), when pairs of birds are spread over much of the forest landscape (although predominantly south of the River Torrens)[40]. The species aggregates in autumn after breeding to form large flocks, concentrating the majority of the region's population into a few localised areas within the region. Forestry SA forests and in particular Second Valley forests are very important as post-breeding areas, where 1,430 (70%) birds were counted in 2011, and 1,083 (68.5 %) birds were counted in 2012[41].

Figure 1 provides an up-to-date map of known records for the species in the Mount Lofty Ranges, based upon data from the Biological Database of South Australia[42] and Birds Australia post 2006 records. Note that only records from the last 25 years have been included, to provide a contemporary overview of distribution. These data show a relatively broad distribution through the Mount Lofty Ranges, with the highest densities of records generally associated with the eastern slopes and higher altitude areas of the Mount Lofty Ranges, with records more sparse on the Adelaide plains, western coastlines, north around Williamstown and east around Strathalbyn.

Importance of Pines as a food source for the Yellow-tailed Black Cockatoo

As noted previously, Yellow-tailed Black Cockatoos have adapted to utilise Pine seed as a food resource. In the Mount Lofty Ranges, both Aleppo Pine (**Pinus halepensis*) and Radiata Pine (**Pinus radiata*) are utilised[43]. Naturally occurring seed plants, such as Hakea, Banksia, Xanthorrhoea and Allocasuarina, are likely to have reduced in abundance and distribution due to vegetation clearance. Pines also provide a significant resource due to the quality and quantity of seed that is produced. An average size Aleppo Pine (8-10 m) has over 1000

[35] Department for Environment and Heritage (undated). Threatened Species Profile Calyptorhynchus funereus Yellow-tailed Black Cockatoo.
[36] Carpenter, G., Price, L.C., Bensen, C. and Van Weenen, J. (2012). Population censuses of Yellow-tailed Black-Cockatoos in the Adelaide and Mount Lofty Ranges – autumn 2011 and 2012. Unpublished report prepared for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.
[37] Gillam, S. and Urban, R. (2014) Regional Species Conservation Assessment Project, Phase 1 Report: Regional Species Status Assessments, Adelaide and Mount Lofty Ranges NRM Region. Department of Environment, Water and Natural Resources, South Australia.
[38] Gillam, S. and Urban, R. (2014) Regional Species Conservation Assessment Project, Phase 1 Report: Regional Species Status Assessments, Adelaide and Mount Lofty Ranges NRM Region. Department of Environment, Water and Natural Resources, South Australia.
[39] Carpenter, G., Price, L.C., Bensen, C. and Van Weenen, J. (2012). Population censuses of Yellow-tailed Black-Cockatoos in the Adelaide and Mount Lofty Ranges – autumn 2011 and 2012. Unpublished report prepared for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.
[40] Carpenter, G., Price, L.C., Bensen, C. and Van Weenen, J. (2012). Population censuses of Yellow-tailed Black-Cockatoos in the Adelaide and Mount Lofty Ranges – autumn 2011 and 2012. Unpublished report prepared for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.
[41] Carpenter, G., Price, L.C., Bensen, C. and Van Weenen, J. (2012). Population censuses of Yellow-tailed Black-Cockatoos in the Adelaide and Mount Lofty Ranges – autumn 2011 and 2012. Unpublished report prepared for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.
[42] This data has been sourced from the South Australian Department for Environment and Water Biological Database of SA. Recordset number DEWNRBDBSA200904-1.
[43] Way, S. L. and van Weenen, J. (2008) Eyre Peninsula Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus whitei*) Regional Recovery Plan. Department for Environment and Heritage, South Australia.

times more seed in the top two thirds of its branches than a whole large size hakea bush[44]. It has been estimated that to replace a row of ten medium-sized Aleppo Pines would require revegetation of 1.77 hectares of Wrinkled Hakea (*Hakea rugosa*)[45].

The retention of large numbers of pinecones on pines in areas where Yellow-tailed Black Cockatoos feed is a good indication of poor seed quality[46]. This may be due to a number of factors, including genetic lineage of the tree, soil type, and density of plantings. In a study of the related Carnaby's Cockatoo (*Calyptorhynchus latirostris*), it was noted that almost the entire annual crop of pine cones in plantations in Western Australia was removed annually[47]. It is therefore also considered likely that the abundance of remnant pine cones on a tree is an indicator of that particular tree not being of long-term importance as a vital food resource.

[44] Way, S. L. and van Weenen, J. (2008) Eyre Peninsula Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus whitei*) Regional Recovery Plan. Department for Environment and Heritage, South Australia.'
[45] Way, S. (2007). Supplementary feeding trial for Eyre Peninsula Yellow-tailed Black-Cockatoos. Unpublished report prepared for the South Australian Department for Environment and Heritage, Port Lincoln.
[46] Jason van Weenen pers. comm.
[47] Stock WD, Finn H, Parker J, Dods K (2013) Pine as Fast Food: Foraging Ecology of an Endangered Cockatoo in a Forestry Landscape. PLoS ONE 8(4): e61145.

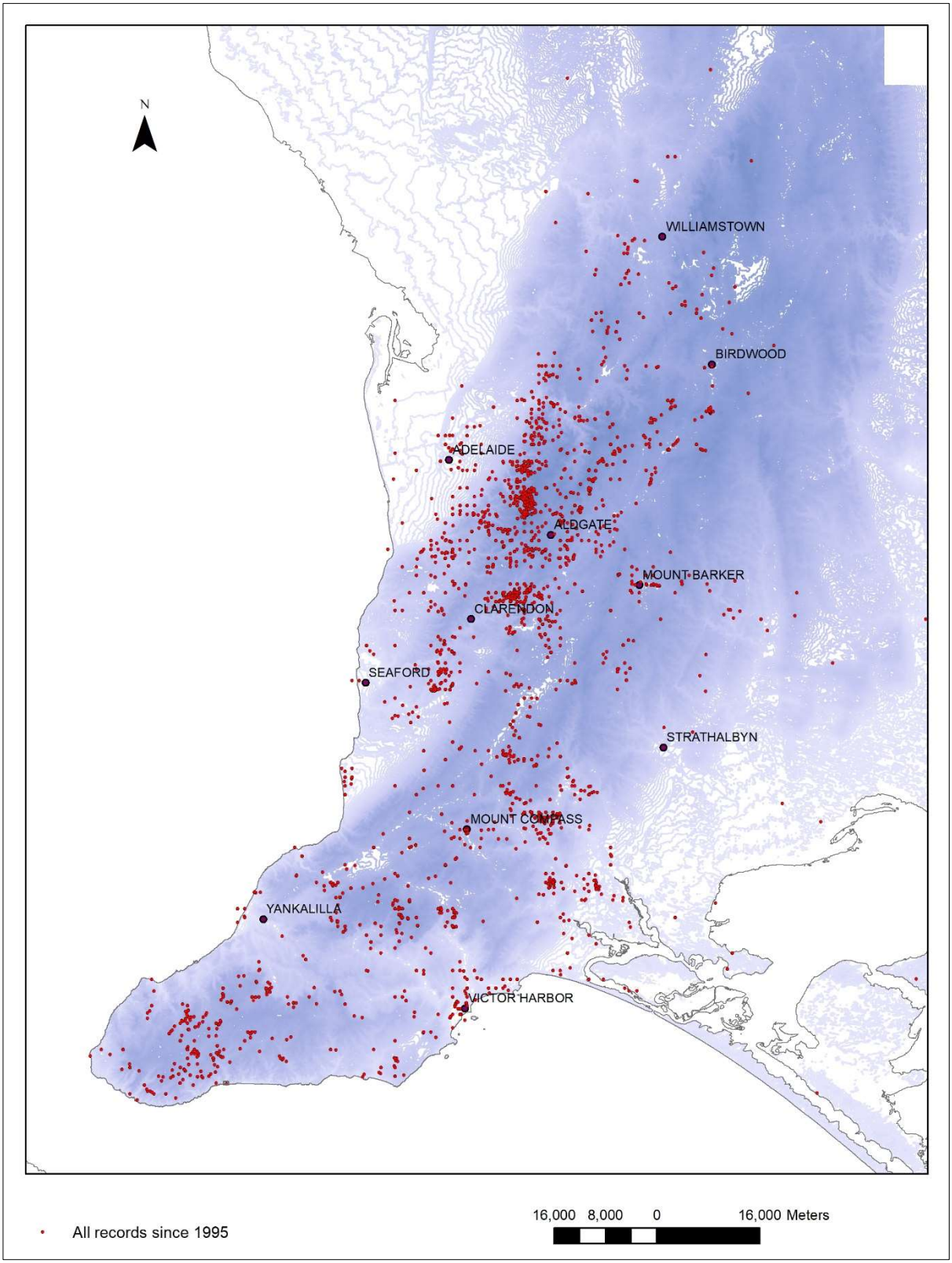


Figure 1: Location records for the Yellow-tailed Black Cockatoo since 1995. Blue shading shows elevation, with darker colour indicating higher elevation.

4. Overview of the Lower Field River / Cormorant Reserve

Cormorant Drive Reserve is situated at the mouth of the Field River in the suburb of Hallett Cove. The reserve includes walking trails, a dinosaur fossil site and a local playground. The Friends of the Lower Field River was established in 2006 to protect and care for the lower portion of the Field River and its environs. Figure 2 shows the location of the Reserve. This area has been identified by the City of Marion as one of two priority sites for management , as well as an 'opportunity vegetation site' to create vegetation corridors across the landscape[48].

In an assessment of the remnant vegetation in the Reserve in 2019, Telfer[49] noted

> "The portion of the reserve to the south of Cormorant Drive supports riparian zone and associated slopes, including large remnant trees, extensive areas of established revegetation (mostly trees and shrubs) with some patchy remnant understorey vegetation present, particularly towards the southern boundary (abutting the rail corridor).
>
> The northern side of Cormorant Drive includes the mouth of the Field River as it flows out to sea. Vegetation communities present include riparian zone, a small patch of Swamp Paper-barks and areas of revegetation."

In an assessment of the remnant vegetation in the Reserve in 2019, Telfer[50] divided the site into 6 key vegetation types, based on vegetation present, landform and current management regimes. These vegetation types are shown in Figure 3, and described below:

Precinct 1
Indigenous revegetation patches which are situated on either side of Cormorant Drive. Much of the vegetation is planted and the sign at this site describes it as a "*Eucalyptus porosa* and *Eucalyptus camaldulensis* Woodland Restoration Site". Some large remnant River Red Gums (*Eucalyptus camaldulensis*) are present.

Precinct 2
Small patches of planted Swamp Paperbark (*Melaleuca halmaturorum*) and Scarlet Bottlebrush (*Callistemon rugulosus*) in the riparian zone in the lower reaches of the Field River.

Precinct 3
This is a River Red Gum (*Eucalyptus camaldulensis*) Very open woodland over dense Common Reed (*Phragmites australis*) and Bulrush (*Typha domingensis*) which occurs in the riparian zone of the Field River. Also present are patches of Large Bindweed (*Calystegia sepium*). Weeds of concern include scattered Olive, Ash, Willow, Fennel, Kikuyu and a range of grasses and herbaceous species.

Precinct 4
This is the areas of open grassy woodland which are mown and maintained as parkland. Remnant River Red Gums [and Aleppo Pines] are present, however very little remnant understorey (if any) is present.

Precinct 5
A small patch of coastal plantings which occur on the side of River Parade (adjacent to the coast).

Precinct 6
Includes the revegetated slopes on the southern side of Cormorant Drive. This area has been described as *Eucalyptus porosa* & *E. camaldulensis* ssp. *camaldulensis* Woodland and comprises mostly planted trees and shrubs over an understorey which is dominated by introduced grasses and herbs. Where the slopes are steep

[48] City of Marion (2018). Remnant Vegetation Management Plan 2018 to 2023. City of Marion, Adelaide.
[49] Telfer, S. (2019). City of Marion Native Vegetation Assessments – 12 Reserves. Unpublished report prepared for the City of Marion Council.
[50] Telfer, S. (2019). City of Marion Native Vegetation Assessments – 12 Reserves. Unpublished report prepared for the City of Marion Council.

and rocky with skeletal soils, remnant native grasses, herbs and sedges persist, including Spear Grass (*Austrostipa* sp.), Wallaby Grass (*Rytidosperma* sp.), Black-head Grass (*Enneapogon nigricans*), Brush Wire-grass (*Aristida behriana*), Kangaroo Grass (*Themeda triandra*), Soft Tussock Mat-rush (*Lomandra densiflora*) and Pink Garland-lily (*Calostemma purpureum*).

Fifty eight (58) plant species considered indigenous to the area were observed during field survey[51], although some of these species may have been introduced to the area as part of revegetation programs. Only one plant species of state or national conservation significance was noted, the state Rare Creeping Boobialla (*Myoporum parvifolium*), although it is considered likely that this species has been reintroduced to the site through plantings rather than being a remnant species (pers. obs.). Overall the site has been heavily disturbed, but retains some native species in sections of the understorey, and provides a good opportunity for biodiversity conservation works in an urban environment.

Fauna present within the site

Two bird surveys have been undertaken in the site in recent times by two different observers, in February 2019 and November 2019. Additional bird species observed during field visits for this study were also included on the list. A total of 34 native species have been observed. The list of these species is provided in Table 1. Whilst a comprehensive list of species would require visits across several occasions over different seasons, this list does provide an indication of the avifauna present in the Reserve. Many of the species noted were associated with the beach and estuarine environment, but twenty three (23) species would be considered to be inhabitants of riparian or woodland environments.

Aside from the Yellow-tailed Black Cockatoo, there were no other species of state or national conservation significance observed, although there were three species considered Vulnerable at a regional level, the Silvereye (*Zosterops lateralis*), Nankeen Night Heron (*Nycticorax caledonicus*) and the Pacific Black Duck (*Anas superciliosa*). In an assessment of the ecological values of the section of Cormorant Drive Reserve between Cormorant Drive and the beach, Telfer[52] noted that it was unlikely that the riparian and woodland areas formed significant habitat for any species of national conservation significance, based upon a review of the literature and known distribution of species.

Table 1: Bird species previously observed in the site and during this study

Species	Common Name	SA	Adelaide Region[53]	Habitat	Record source
Falco longipennis	Australian Hobby		Least Concern	Flying over riparian	2
Gymnorhina tibicen	Australian Magpie		Least Concern	Widespread	2
Acrocephalus australis	Australian Reed Warbler		Least Concern	Riparian	1,2
Coracina novaehollandiae	Black-faced Cuckooshrike		Least Concern	Noted south of Cormorant Drive	2
Ocyphaps lophotes	Crested Pigeon		Least Concern	Riparian	1,2
Platycercus elegans	Crimson Rosella		Least Concern	In trees	2
Gallinula tenebrosa	Dusky Moorhen		Least Concern	Riparian	1
Larus pacificus pacificus	East Coast Pacific Gull		Vulnerable	Intertidal/beach; estuary	1,2
Thalasseus bergii	Greater Crested Tern		Vulnerable	Intertidal/beach; estuary	1,2

[51] Telfer, S. (2019). City of Marion Native Vegetation Assessments – 12 Reserves. Unpublished report prepared for the City of Marion Council.
[52] Telfer, S. (2019). City of Marion Native Vegetation Assessments – 12 Reserves. Unpublished report prepared for the City of Marion Council.
[53] As per Gillam, S. and Urban, R. (2014) Regional Species Conservation Assessment Project, Phase 1 Report: Regional Species Status Assessments, Adelaide and Mount Lofty Ranges NRM Region. Department of Environment, Water and Natural Resources, South Australia.

Species	Common Name	SA	Adelaide Region[53]	Habitat	Record source
Anas gracilis	Grey Teal		Least Concern	Intertidal/beach; estuary	1,2
Megalurus gramineus	Little Grassbird		Near Threatened	Heard calling from upstream	Current study
Microcarbo melanoleucos	Little Pied Cormorant		Least Concern	Intertidal/beach	1
Corvus mellori	Little Raven		Least Concern	Noted as widespread	2
Grallina cyanoleuca	Magpielark		Least Concern	Intertidal/beach; estuary	1,2
Nycticorax caledonicus	Nankeen Night Heron		Vulnerable	Noted in pines	Current study
Phylidonyris novaehollandiae	New Holland Honeyeater		Least Concern	Riparian	1,2
Anas superciliosa	Pacific Black Duck		Vulnerable	Riparian	1,2
Phalacrocorax varius	Pied Cormorant		Least Concern	Intertidal/beach; estuary	1,2
Trichoglossus haematodus	Rainbow Lorikeet		Least Concern	In trees	2
Anthochaera carunculata	Red Wattlebird		Least Concern	Riparian, common	1,2
Platycercus sp.	Rosella		Least Concern	Dune	1
Chroicocephalus novaehollandiae	Silver Gull		Least Concern	Intertidal/beach; estuary	1,2
Zosterops lateralis	Silvereye		Vulnerable	In trees	2
Gavicalis virescens	Singing Honeyeater		Least Concern	Dune	1
Haematopus fuliginosus fuliginosus	Sooty Oystercatcher	Rare	Endangered	Intertidal/beach	1
Vanellus miles novaehollandiae	Southern Masked Lapwing		Least Concern	Intertidal/beach	1,2
Cacatua galerita	Sulphur-crested Cockatoo		Least Concern	Noted in pines	Current study
Malurus cyaneus	Superb Fairy-wren		Least Concern	Riparian	1,2
Sericornis frontalis	White-browed Scrub-wren		Least Concern	Riparian	1
Egretta novaehollandiae	White-faced Heron		Least Concern	Intertidal/beach	1
Ptilotula penicillata	White-plumed Honeyeater		Least concern	Towards southern end of Reserve	2
Rhipidura leucophrys	Willie Wagtail		Near Threatened	Dune	1,2
Calyptorhynchus funereus	Yellow-tailed Black Cockatoo		Vulnerable	Noted in pines	Current study

Record/source: 1 = Telfer, S. (2019). Flora and fauna assessment Coast Park- Hallett Cove. Unpublished report for the City of Marion, 2 = Gitsham, J. (2019). Lower Field River Reserve Bird Monitoring.

With regard to reptiles in the site, Telfer[54] notes:

> "The coastal foredunes were relatively open, and would only provide limited habitat value for reptiles. The open woodlands along the Field River would provide some habitat niches for reptiles, although generally only widespread species able to cope with limited habitat areas and disturbance. Whilst up to 11 species may possibly occur in the site, none are of State or National conservation significance."

The riparian zones are also likely to provide habitat for frogs, with the Common Froglet (*Crinia signifera*) and Spotted Grass Frog (*Limnodynastes tasmaniensis*) considered likely to be present, and the Eastern Banjo Frog

[54] Telfer, S. (2019). Flora and fauna assessment Coast Park- Hallett Cove. Unpublished report for the City of Marion.

(*Limnodynastes dumerilii*) and Brown Tree Frog (*Litoria ewingii*) also possibly present. None of these species is of state or national conservation significance, but the Brown Tree Frog is considered Rare at a regional level.

Figure 2: Cormorant Drive Reserve. Approximate boundary of Reserve shown in red

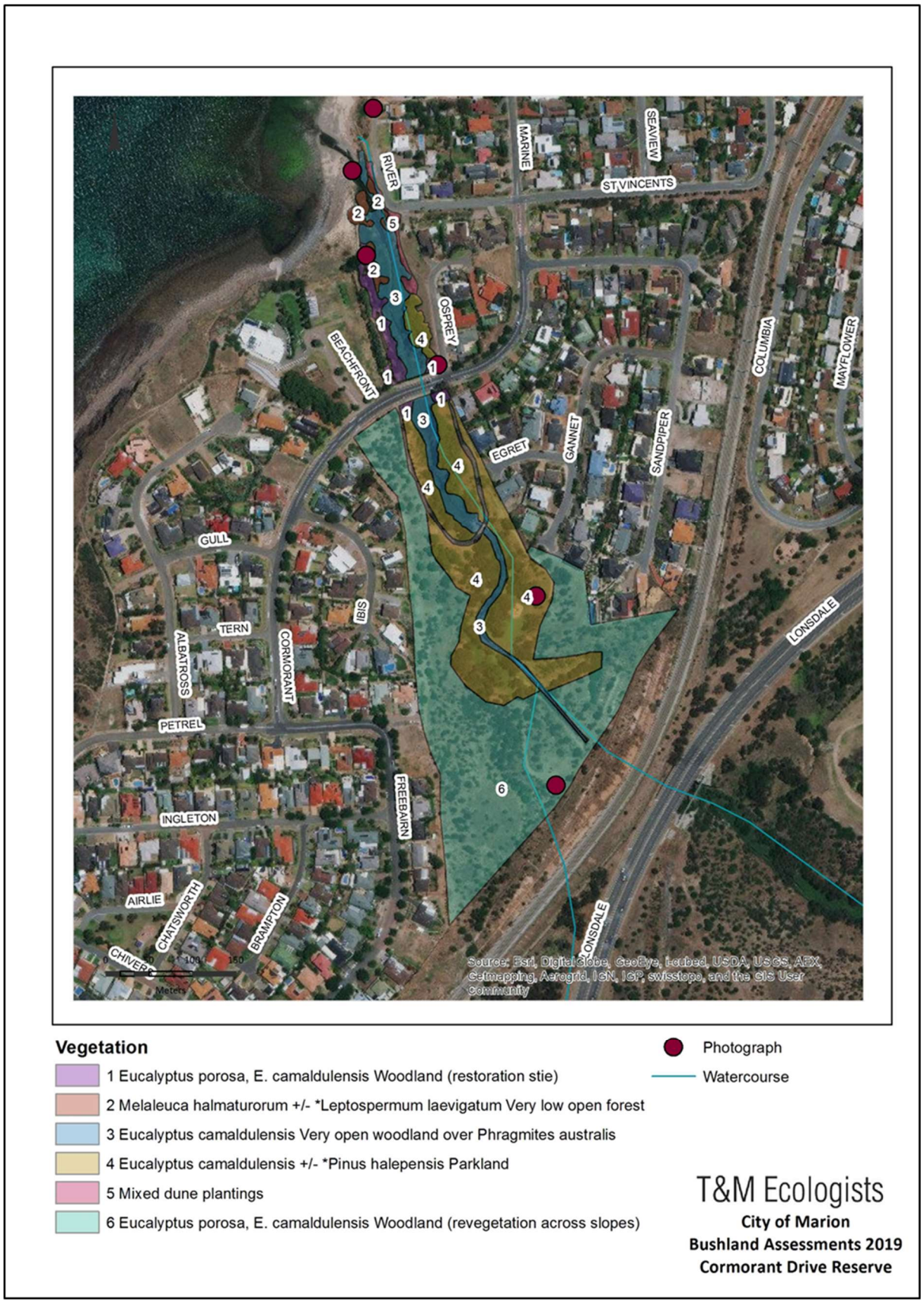


Figure 3: Vegetation types present in Cormorant Drive Reserve. Reproduced from Telfer 1999[55].

[55] Telfer, S. (2019). City of Marion Native Vegetation Assessments – 12 Reserves. Unpublished report prepared for the City of Marion Council.

5. Aleppo Pines present in the site

Thirty four (34) Aleppo Pines are the focus of this investigation, in two main clusters to the north (12 trees) and south (22 trees) of Cormorant Drive (see Figure 4)[56]. An arborist assessment in August 2020 (attached as Appendix 1) noted that the health and/or structure of over half of the trees assessed was rated as poor. The report also provided a staged plan for removal across six years, based upon an assessment of the condition, size and amenity value of the tree, with the largest trees in best condition and with high amenity value left until the final year for removal. This report has been included as Appendix 1.

6. Field assessment and observations

As part of this report, the site was visited on two occasions, on Monday 24th of August, and Thursday 10th of September. At the first visit, no Yellow-tailed Black Cockatoos were observed in the Aleppo Pines in Cormorant Drive Reserve, but a flock of 19 Yellow-tailed Black Cockatoos was observed feeding in a nearby stand of Aleppo Pines to the west of Cormorant Drive Reserve (location shown in Figure 5).

With regard to the Cormorant Drive Aleppo Pines, observations of the ground underneath the trees showed at that point in time, there had only been recent detectable feeding (as evidenced by recently chewed cones as shown in Figure 6) in tree number 31 (Figure 4). It is notable that this tree is considered to be one of the two largest tees in the site, and is proposed to be one of the final trees for removal (see Appendix 1).

On the second visit to the Cormorant Drive site, there was indication of widespread feeding (most likely by Yellow-tailed Black Cockatoos) in most of the Aleppo Pines in the site (both north and south of Cormorant Drive), although no Yellow-tailed Black Cockatoos were observed on the day. Nearby residents had noted up to 200 Yellow-tailed Black Cockatoos feeding in the trees between the two inspection dates[57]. It was also notable that at this second visit, two Nankeen Night Herons (*Nycticorax caledonicus*) were flushed from tree 1 on the north side of Cormorant Drive whilst examining trees. These birds subsequently flew and landed in nearby revegetated Red Gums on the other side of the Field River. This species is likely present due to the dense protective cover provided by both the pines, and the dense stand of Swamp Paperbark (*Melaleuca halmaturorum*) near the entrance of the Field River, along with the feeding opportunities provided by the river/estuarine environment.

Most of the Aleppo Pines had heavy to very heavy loadings of pine cones that had already shed seed (see Figure 7). Canopy cover was dense, and there were few native understorey plants present, with only scattered Common Reed (*Phragmites australis)* around creek edges. It was also noted that many of the pines along creek edges, especially south of Cormorant Drive, were leaning inwards towards the centre of Field River (Figure 8), and would be likely dropping significant quantities of pine needles into the waterway.

[56] Cassar, S. (2020). Aleppo Pine Management Plan – Cormorant Drive Reserve, Hallett Cove. Unpublished report prepared for City of Marion.
[57] Morriss, D. (2020). Yellow-tailed Black Cockatoos feeding Lower Field River Hallett Cove 2020.

Figure 4: Location of Aleppo Pines surveyed as part of this report. Figure reproduced from Cassar (2020) [58].

[58] Cassar, S. (2020). Aleppo Pine Management Plan – Cormorant Drive Reserve, Hallett Cove. Unpublished report prepared for City of Marion.

Figure 5: Location of adjoining area of Aleppo Pines being used for feeding by Yellow-tailed Black Cockatoos (circled in blue)

Figure 6: Recently chewed pinecones

Figure 7: Indicative photograph of the heavy loading of open pinecones in the Aleppo Pines in the site

Figure 8: Significant lean on Aleppo Pines along the verges of the Field River

7. Discussion:

The two dense stands of Aleppo Pines in Cormorant Drive Reserve are providing a food resource for the State Vulnerable Yellow-tailed Black Cockatoo, and also shelter and perching habitat for other species, including the regionally Vulnerable Nankeen Night Heron (*Nycticorax caledonicus*). It should be noted that the trees may also attract the Little Corella (*Cacatura sanguinea*) and Sulphur-crested Cockatoo (*Cacatua galerita*) which, unlike Yellow-tailed Black Cockatoos, are noisy and have the potential to damage nearby property[59].

The Pines are having a negative impact on local ecosystems in a number of ways. The heavy cover of pines is shading out other species and preventing regeneration. The heavy layer of needles is modifying soil conditions, and preventing establishment of native seedlings. The dense cover and poor ground layer is restricting basking opportunities for reptiles, and the depauperate understorey would provide little feeding habitat for birds. The pines would also be dropping significant quantities of needles into the Field River, and likely impacting water quality. The presence of pines is also precluding native plant species that could provide useful resources for native fauna, such as flowers for nectar and berries. Their seed, spread by the wind, is likely to blow away and cause seedling pines to emerge in other areas, including in other sections of the Cormorant Drive Reserve. It is also notable that the species is declared under the *Landscape South Australia Act 2017*, which obligates the City of Marion to control the species on land under the Council's control.

An arborist has prepared a staged proposal for removal of the Aleppo Pines across a six year timeframe, based upon the condition, size and amenity value of each individual tree, with the largest trees in best condition and with high amenity value left until the final year for removal. This staged plan for removal is considered unlikely to have an overall impact on the Yellow-tailed Black Cockatoo population in the Mount Lofty Ranges. The presence of a substantial quantity of old cones on the Pines (ie uneaten by Yellow-tailed Black Cockatoos) indicate that, across the longer term, these particular pines may not form a critical resource for the Cockatoos.

[59] Chris Daniels, pers. comm.

The presence of a nearby stand of Aleppo Pines mean that Yellow-tailed Black Cockatoos are still likely to feed in the local area.

When contacted for comment, Jason van Weenen[60], Species Ecologist for the Department for Environment and Water, noted that thinning of Aleppo Pines may improve seed production and quality in the pines that remain, and that retention of a small number of pines in the site may provide the dual outcome of reducing the negative impacts of dense stands of pines, but continuing to provide resources for the Yellow-tailed Black Cockatoo.

Graham Carpenter, Bird Record Secretary for BirdsSA, was also contacted to see if this organisation had a formal position on this issue. He noted that "Birds SA doesn't have an official position but recognises on one hand that pines provide an important food for a state-listed threatened species, and on the other hand that pines are a weed in areas with significant native vegetation where they compete with native species.

Management therefore has led to a compromise position of progressively removing the pines that are causing the main management problems (the source of seedlings), particularly those in roadside vegetation and in areas reserved for native vegetation. Another compromise position could involve selective planting of non-invasive pine species that are known to be used by Yellow-tailed Black Cockatoos (e.g .*Pinus pinea*) in a dedicated area, recognising that they will take several years to produce reasonable numbers of cones. This would then require a management strategy over a number of years rather than removing all the existing pines up front. No other native species will produce the same amount of food or be likely to attract Yellow-tailed Black Cockatoos to the area with the exception of exotic banksias and hakeas, which are generally slower growing and shorter lived in South Australia." These comments are in keeping with the recommendations of this report, although planting of the exotic *Pinus pinea* would not be considered appropriate in Cormorant Drive Reserve (due to its current and future biodiversity value), but could be considered by City of Marion for Reserves that are devoted to recreation or other values.

The six year planned removal proposed by the arborist is considered to be a sensible and logical approach to removal of Aleppo Pines in Cormorant Drive Reserve. The staged and targeted removal of trees in poor health or poor form is removing the trees likely to be of least value for Yellow-tailed Black Cockatoos first. This approach also provides an opportunity to review at various stages of the project, with the largest trees in best condition left until year 6 of the removal program. The approach taken to removal thus ensures the trees most likely to provide the greatest resources are not removed until last. If any new information should emerge regarding the importance of this stand of Aleppo Pines to Yellow-tailed Black Cockatoos (as it relates to the survival of the species), consideration could be given to retention of a small number of trees.

A revegetation plan, following pine removal, is included in Appendix 2. It should be noted that revegetation in the site is unlikely to provide the same level of food resources even if known food native plants are utilised (such as Hakeas and Allocasuarinas), due to both a lower seed output by these native plants compared to Aleppo Pines, as well as the likelihood that the Cockatoos will preferentially seek out Aleppo Pines over these native species. Notwithstanding this, some of the species present in the Reserve and in the revegetation proposed (see Appendix 2) could potentially provide seed resources if Aleppo Pine seed was in short supply. The six year plan for removal provides opportunities for existing revegetation, along with a concurrent program of revegetation, to provide habitat values for a broader suite of species than are currently provided by the dense stand of pines. This includes resources currently lacking under the Aleppo Pines, such as medium and low shrubs for perching and shelter, seed, berry and nectar resources, and sunlight for ectothermic species to bask.

[60] Jason van Weenen worked extensively on the Eyre Peninsula population of the Yellow-tailed Black Cockatoo, along with supporting censuses for the species in the Mount Lofty Ranges

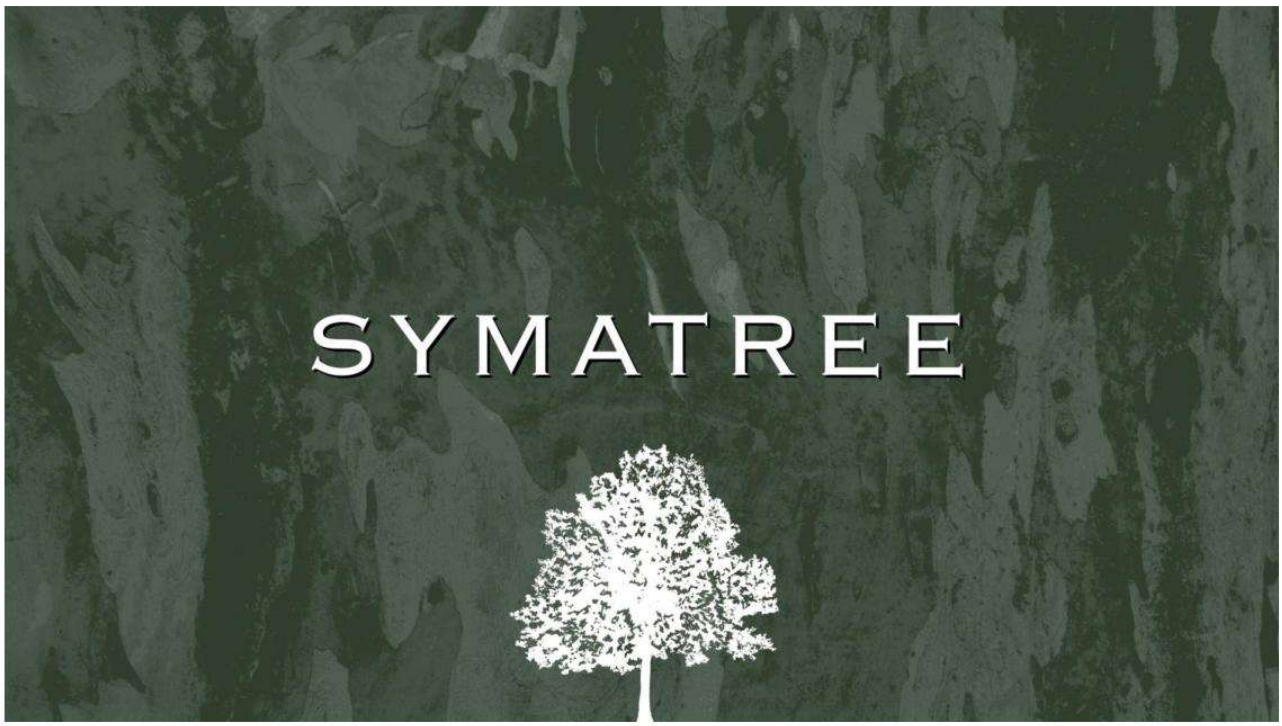
In addition, the planting of species that can form tree hollows of sufficient size for nesting of Yellow-tailed Black Cockatoos, such as Red Gums (*Eucalyptus camaldulensis var. camaldulensis*), would be considered to provide potential future nesting sites, albeit that the hollows would likely take well in excess of 100 years to form. Within the Hallett Cove area, the Red Gum is considered to be the only indigenous tree species that could form suitable nesting habitat for the Yellow-tailed Black Cockatoo. Other trees indigenous to the local area (eg *Eucalyptus porosa, Allocasuarina verticillata*) are generally smaller in form and would not form hollows of sufficient size. Red Gums in the Hallett Cove area will only grow along drainage lines and therefore have a very limited potential range. As such, the removal of Aleppo Pines to be replaced with Red Gums may provide a long-term resource that is currently lacking in the site, along with the Hallett Cove area more generally. Other species will also utilise the hollows that will eventually form, providing a resource that is much depleted in the Mount Lofty Ranges.

Following Aleppo Pine removal, it is considered likely that the local environment will respond well to revegetation efforts, providing associated site preparation and ongoing weed control is undertaken. In a six year timeframe, it is estimated that Red Gums would reach a size of 3-5 metres[61], and would be providing nectar resources within 10 years[62]. Red Gums previously planted in the site, considered likely to be ten to fifteen years of age, are about 7-9 metres in size, and by the end of a further six years will be all be in excess of ten metres in height. These Red Gums will provide perching resources for most of the birds that currently perch in the Aleppo Pines. In addition, it is recommended that dense plantings of Swamp Paperbark (*Melaleuca halmaturorum*) are undertaken along northern sections of the creek, to provide a dense overstorey for the Nankeen Night Heron (*Nycticorax caledonicus*), as this species is considered likely to require a more dense canopy than that provided by Red Gums.

Overall it is recommended that the six year plan for removal of the Aleppo Pines is followed, provided that suitable concurrent revegetation programs are undertaken. It is also recommended that an ecologist re-evaluate the site after three years, and provide an up-to-date review of the effectiveness of the Aleppo Pine removal, an evaluation of the revegetation being undertaken and an update of any current research as it relates to Aleppo Pines and importance to Yellow-tailed Black Cockatoos.

[61] Pers. obs.
[62] Tim Croft pers. comm.

Appendix 1: Aleppo Pine Management Plan Cormorant Drive Reserve



Aleppo Pine Management Plan – Cormorant Drive Reserve, Hallett Cove

Report prepared for

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Coordinator Biodiversity
City of Marion
August 2020

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Cert.3 (Hort), Dip. (Hort 5), Dip. (Arb 5), B.App. Sc (Hort), Grad. Dip. Design (Land.)

Table of Contents

Introduction

Purpose of this Document

This plan is concerned with the Aleppo Pines located within the study area as identified on the aerial image referred to as Figure 1.

Figure 1. Cormorant Drive Reserve, study area is highlighted.

The purpose of the Aleppo Pine Management Plan is to provide Council with a clear management direction to guide the staged removal of the two stands of Aleppo Pines at Lower Field River.

This plan involves the review, collection, analysis of relevant environmental and aboricultural data so a succession plan can be developed to help guide the gradual replacement of the Aleppo Pines with local indigenous species,

Site Visit

I carried out site inspection on the 4 August 2020.

Limitations

This report is limited to the time and method of inspection. The trees were inspected from ground level only. Neither a climbing inspection or a below-ground investigation was performed. No soil or plant material samples were taken for laboratory analysis.

This report reflects the state of the trees as found on the day. Any changes to site conditions or surrounds, such as construction works undertaken after the inspection, may alter the findings of the report.

Due to data inaccuracies 26 has not been used as a unique identifier.

Date of Report

This report was written on the 6 August 2020.

Site

Cormorant Drive Reserve is in the suburb of Hallett Cove. The reserve is situated on either side of Cormorant Drive and is 7.27 hectares in size.

The reserve consists of the Field River's estuary at Hallett Cove Beach and nearby sand dunes (refer Figure 2). Coupled with the river, this area provides a cool natural setting for visitors in summer.

The current vegetation in the area is a mix of native, local indigenous and exotic with areas of the reserve having been restored by the Friends of Lower Field River. Some areas are quite degraded with a variety of weed species present.

Figure 2. Field River, facing west from Cormorant Drive Bridge.

Policy Context

There are several State Government and Council policies and strategies that inform the management of Aleppo Pines across the Council.

Aleppo Pine (*Pinus halepensis*) is a declared weed in South Australia as enforced by the Natural Resources Management Act 2004.

The following sections of the NRM Act apply to Aleppo Pine in the Adelaide and Mount Lofty Ranges region (not planted and maintained for amenity or commercial purposes):

- 175 (2) Cannot transport the plant, or any material or equipment containing that plant, on a public road
- 177 (1) Cannot sell the plant
- 182 (2) Landowner must control the plant on their land
- 185 (1) NRM authority may recover costs for control of weeds on roadsides from adjoining landowners

City of Marion's own policy documentation reflects the Natural Resources Management Act 2004 in respect of all declared woody weeds. Council's Remnant Native Vegetation Plan 2018 - 2023, 'Principles Underpinning our Remnant Native Vegetation Management:

> *The City of Marion will remove and actively manage pest plants declared by the minister with the Natural Resources management Act 2004. In revegetation and where possible in landscaping we will use local indigenous species. Where local indigenous plants are used they must be of local provenance to preserve genetic diversity*

The City of Marion takes the approach of:

- *Protecting and maintaining landscapes and biodiversity that we already have.*
- *Enhancing areas that have become degraded, e.g. through revegetation.*
- *Control pest plants from spreading or becoming established.*

Council's Tree Management Framework 2018 also refers to the NRM Act 2004 and the Community Plan and Environment and Biodiversity Strategy. There is also specific principles within the Urban Tree Strategy:

Principle 1; Tree Removal, sub-section D4.3 which states:

> *Address trees classified as environmental weed species, considering the impacts removal will have on the overall aesthetic appearance of the park or reserve..*

Principle 2. D10.3 Tree Removal, sub-section 4.3 which states:

> *Target weed species for removal when deemed to be inappropriately located or causing issues to public or private property.*

Methodology

Tree Schedule

For each tree assessed the following information was collected. This information is recorded in the tree schedule (included as Appendix A).

Tree (Identifier Number - No) and Location

Each tree's location is identified using its unique identifier number. The identifier numbers used in the tree schedule correspond with those on the aerial images included as part of Figures 5 and 6.

Species

Tree names are provided as botanical names only.

Tree Height

Height is estimated and recorded as follows:

- Less than 5 metres
- 5 – 10 metres
- 10 – 20 metres
- Greater than 20 metres

Trunk Circumference

An actual measure of trunk circumference at 1 metre from ground was taken for each tree within the study area.

Structure

Overall structure is rated using one of the following categories:

- Good: Trees that are typical of the species with a structure that is free from notable defects fall within this category. Some maintenance pruning may be identified as required for subject trees/ shrubs that fall within this category.
- Fair: This category includes those trees that may have one or more of the following structural defects: minor bark inclusions, co-dominant leaders, minor trunk wounding or decay, branches that are overextended or end weighted, poor pruning history, leaning trunk, unbalanced canopy, moderate epicormic growth or a history of minor branch failures. Remedial and/or maintenance pruning is typically identified as required to address these structural issues.
- Poor: This category includes those trees that may have one or more of the following structural defects: co-dominant leaders with major bark inclusions, major bark inclusions present within the canopy, dieback to a significant proportion of the canopy, a history of major branch failure, a severely leaning trunk, extensive decay or wounding, excessive end-weighted and over-extended branches, excessive epicormic growth, root damage or the tree instability. Remedial and/or maintenance pruning typically will not address these structural issues identified in this category. Generally, removal is the only available option.

Methodology (cont)

Health

The health and condition of a tree/ shrub is determined by its overall appearance, foliage colour, density, vigour and the presence/ absence of pests and diseases within the crown. Specifically, tree health and condition is categorised as one of the following:

- Good: This category includes trees that are growing vigorously, have no or only minor pest or disease infestation, only a small amount of dead wood present within the canopy, and good aesthetic appeal.
- Fair: This category includes trees with moderate growth rate, foliage density and vigour, moderate pest or disease infestation, minor growing tip dieback, a moderate amount of dead wood, and where aesthetic appeal is lacking and other stress factors are present.
- Poor: This category includes trees with low growth rate, poor foliage density and vigour, dieback to a significant proportion of the canopy, a high level of pest or disease infestation, a large amount of dead wood within the canopy, and that lacks aesthetic appeal and/or have other signs of severe stress.

Removal Program

- Years 5 and 6: The tree is a mature specimen in fair to good condition with a useful life expectancy of at least 10 years is located such that its loss would have a significant impact on the landscape.
- Years 3 and 4: The tree is a semi-mature or mature specimen, in fair to good condition that is suitable for retention; however, is located such that its loss would not have a significant impact on the landscape.
- Year 2: The tree is likely to be juvenile or in structure decline or declining health and could be retained for a short period of time.
- Year 1: The tree should be removed as it is in severe decline, hazardous or dead.

Comments

The principle observations of the subject tree.

Findings

Study Area

The study area is located either side of Cormorant Drive, adjacent to the bridge, on the northern side of Field River. The trees are split into two clumps, twelve trees located on the western side (refer Figure 3) and Twenty-Two Trees on the eastern side (refer Figure 4). Total of 34 Trees.

The trees are planted in informal lawn areas or located within the clumps of Phragmites. Mixed plantings of local indigenous species can be found near the trees.

Figure 3. Study area looking southwest.

Figure 4. Study area looking southeast.

The approximately location of these trees is identified on the aerial image refer Figure 5. The main findings from the survey are as follows:

Findings (cont)

Figure 5. Aerial image indicating approximate location of the trees that are the subject of this management plan.

Findings (cont)

Tree Health and Structure

Trees 2, 3, 7, 14, 18, 19, 24, 25, 27 and 28 have been identified as being poor health. These trees have reached the end of their useful lives and are in decline. Moderate to high volumes of dead wood and /or leafless areas have been noted within their respective crowns.

Trees 5, 12, 15,18, 19, 21, 23, 25, 27, 28 and 33 have been identified as being in poor structure. There are several causes of a decline in structure ratings including:

- Poorly formed branch unions
- Evidence of previous failure/s
- Overall poor form, top heavy, unbalanced crowns, due to overshadowing from adjacent trees

The remaining trees have been identified as being in fair health and structure.

Appraisal

Existing Trees

It appears most of these trees are self-sown that were left to mature and originate from either the two largest, trees 22 and 31 or external sources. Majority of these trees have trunk circumferences of less than 2 metres and have yet to achieve their full growth expectation.

These trees do provide a strong visual presences/appeal within the locality and are a prominent feature within the reserve. As a group their aesthetic value is high and they make an important contribution to the landscape character and amenity of the local area. This and other mature trees and vegetation within the reserve create a massing effect with the subject trees providing an impressive focal point as one enters the reserve from Cormorant Drive.

The health and/or structure of over half of the trees assessed have been rated as poor. The majority of these trees are poorly formed and or have defective branch unions. Of particular concern is many of these trees are in declining health with moderate level of dead wood. Aleppo Pines are a species that does not respond well to regeneration.

Appraisal (cont)

Action Plan – Removal Program

The removal program is identified on the aerial image below, refer Figure 6.

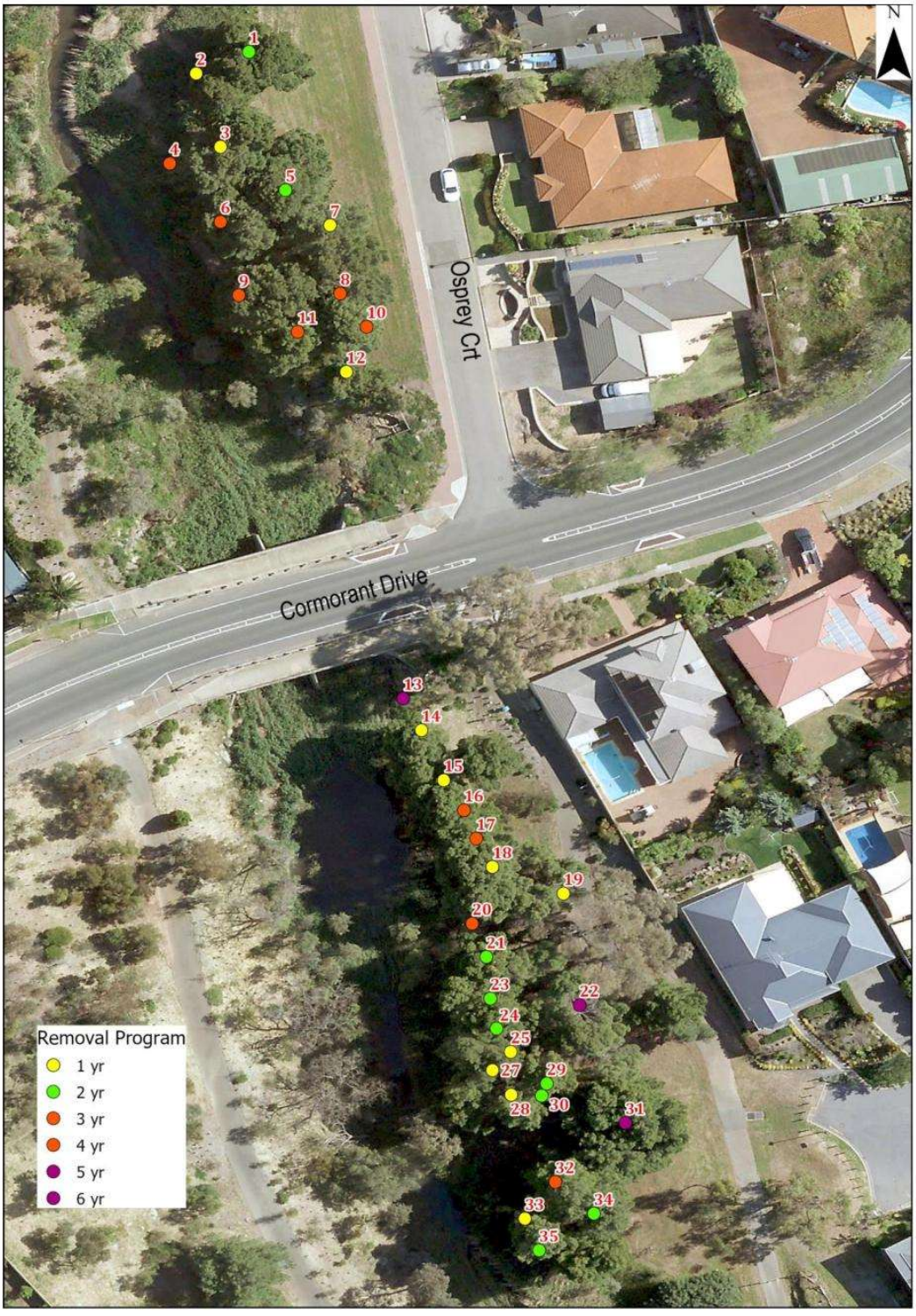


Figure 6. Removal program, years 1 – 6 indicated in various colours.

Appraisal (cont)

Stage 1

Remove in the first instance trees 2, 3, 7, 12, 14, 15, 18, 19, 25, 27, 28 and 33 have been assessed to be in poor health and/or structure or these trees are small and their removal will have limited impact to the visual amenity of the reserve. Stage 1 tree removals should occur within 12 months.

Stage 2

The next stage Trees 1, 5, 21, 23, 24, 29, 30, 34 and 35 have been assessed to be in fair health and fair to poor structure and do not pose an immediate risk at this time.

The retention of these trees will for a period soften the loss of stage 1 trees and allow the establishment of replacement plantings from an amenity and bank erosion perspective. Stage 2 tree removals should occur within 24 months.

Stage 3

The next stage Trees 4, 6, 9, 10, 11, 16, 17, 20 and 32 have been assessed to be in fair health and fair structure.

Tree retention, until years 3 and 4 will allow replacement species to mature and soften the loss of amenity once removal of these trees occur and reinforce the protection of the banks from erosion. Stage 3 tree removals should occur within 36 to 48 months.

Stage 4

The next stage Trees 13, 22 and 31 have been assessed to be in fair to good health and fair to good structure. In addition, Trees 22 and 31 are the largest trees within the immediate locality.

Tree retention, until years 5 and 6 will provide opportunity to allow replacement species to mature and soften the loss of amenity once removal of these trees occur. Stage 4 tree removals should occur within 60 to 72 months.

Tree Pruning

The MFS have advised the Aleppo Pines are not a fire risk, however it has been suggested the crowns be uplifted to reduce connectivity to the ground vegetation layer in year 1 of the removal program.

Therefore, trees identified for removal in years 2 – 6 should be crown lifted to at least 3 metres from ground. This work could be completed concurrently with the removal of Year 1 trees.

Conclusion

In total, 34 Aleppo Pines were identified within the study area. It is possible Trees 22 and 31 given their maturity and size were initially planting. I suggest the remaining trees are all self-sown, originating from either the initially planted trees or external sources and left to mature.

The health and structure of over half of the trees assessed has been rate as poor. Most of these trees are poorly formed and / or have defective branch unions. In addition, many of these trees are in declining health with moderate to high levels of dead wood with a history of branch failure.

Tree removal is recommended to occur in a staged process over a six-year period with most trees removed in Stages 1 and 2.

Pruning to crown lift to at least 3 metres from ground the remaining trees should occur concurrently in year 1 for those trees identified for removal in subsequent years.

Recommendation

The following tree removal action plan be adopted:

- Stage 1 – Remove trees 2, 3, 7, 12, 14, 15, 18, 19, 25, 27, 28 and 33. Tree removals should occur within 12 months.
- Stage 2 – Remove trees 1, 5, 21, 23, 24, 29, 30, 34 and 35. Tree removals should occur within 24 months.
- Stage 3 - Remove trees 4, 6, 9, 10, 11, 16, 17, 20 and 32. Tree removals should occur within 48 months.
- Stage 4 - Remove trees 13, 22 and 31. Tree removals should occur within 72 months.

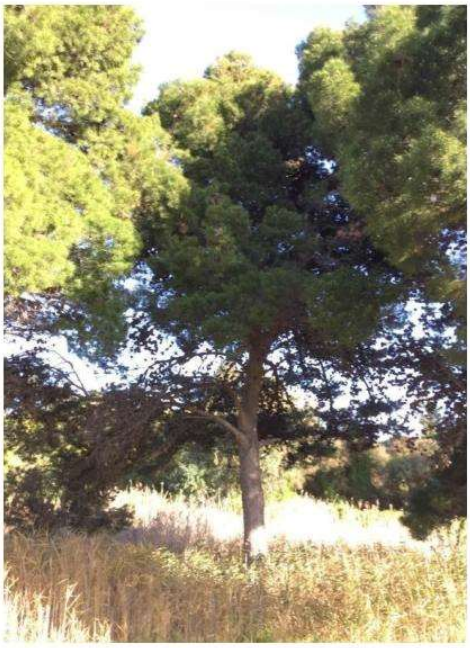
Trees identified for removal in years 2 – 6 should be crown lifted to at least to 3 metres from ground. This work could be completed concurrently with the removal of Year 1 trees.

Sam Cassar

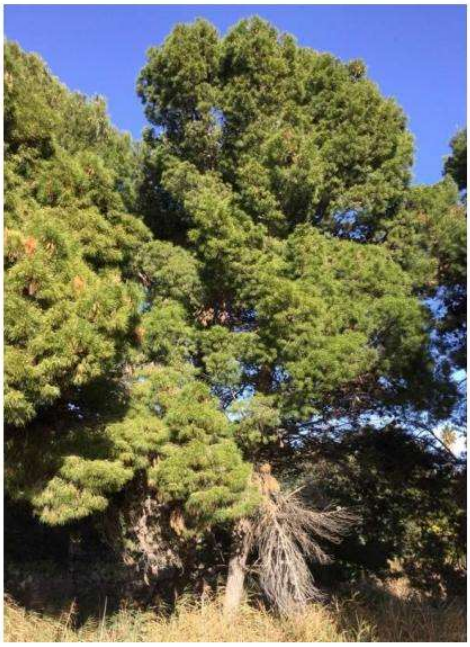
Appendix A
Tree Schedule

Tree ID	**1**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.75 & 1.64m
Removal Program	2 yr
Comments	Die back due overshadowing southern side, crown in contact ground, crown requires lifting. 30% overall crown is dead.

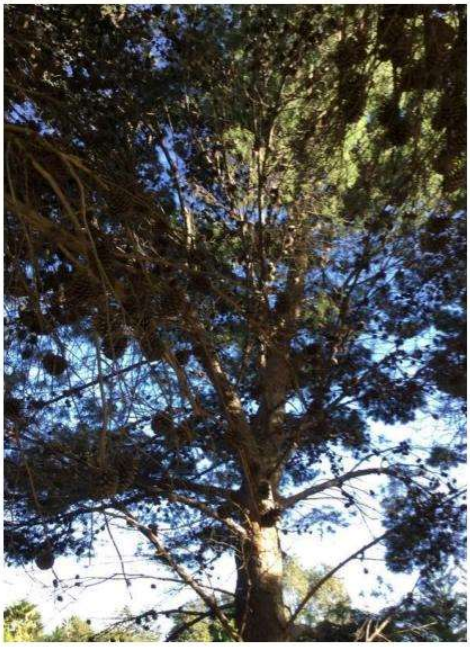
Tree ID	**2**
Species	Pinus halepensis
Height	10-20m
Health	Poor
Structure	Fair
Circumference	1.52m
Removal Program	1 yr
Comments	History of branch failure. Die back southwest side due overshadowing.



Tree ID	**3**
Species	Pinus halepensis
Height	10-20m
Health	Poor
Structure	Fair
Circumference	1.25m
Removal Program	1 yr
Comments	Approximately 50% crown dieback apparent. Crown bias west.

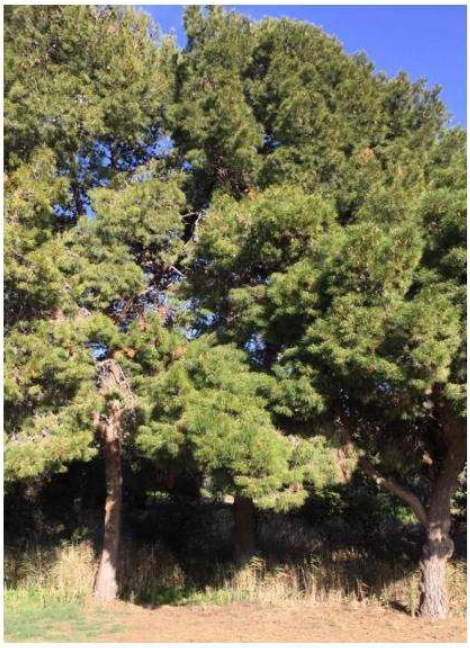


Tree ID	**4**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.75m
Removal Program	3 yr
Comments	Crown lift required to 3 metres.

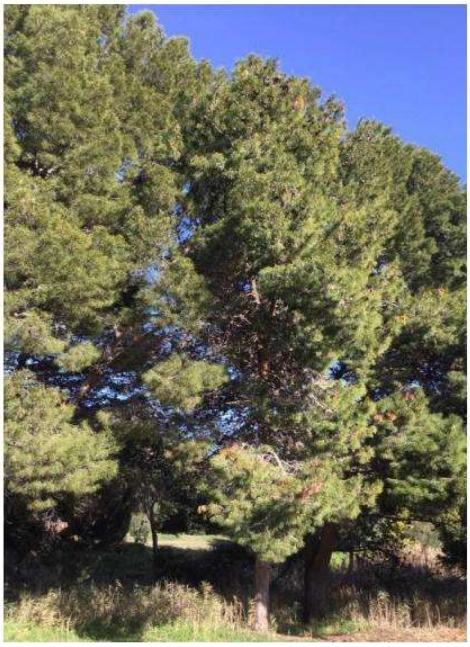


Tree ID	**5**
Species	Pinus halepensis
Height	5-10m
Health	Fair
Structure	Poor
Circumference	1.56m
Removal Program	2 yr
Comments	History branch failure, 50% crown dieback southern side. Tree stunted overshadowed by larger tree to southeast.

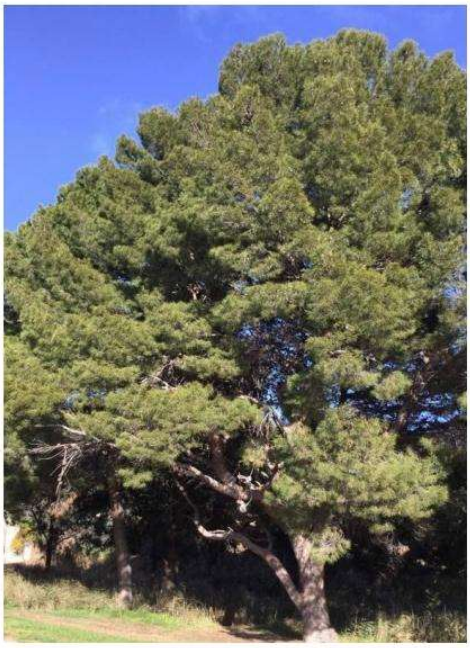
Tree ID	**6**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	2.42m
Removal Program	4 yr
Comments	Approximately 20% crown dieback due to overshadowing. Crown lift to 3 metres.



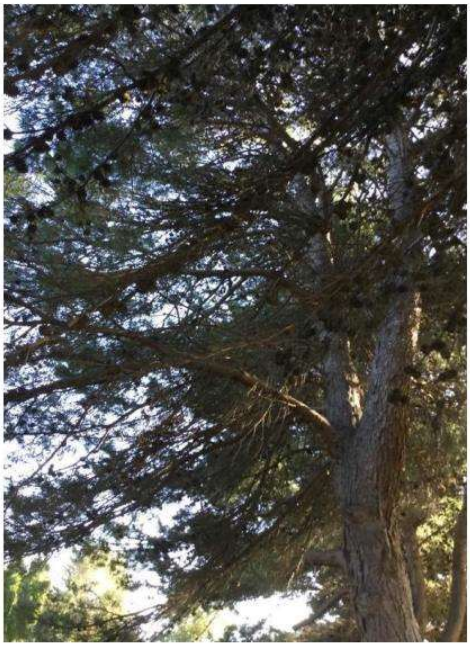
Tree ID	**7**
Species	Pinus halepensis
Height	10-20m
Health	Poor
Structure	Fair
Circumference	1.33m
Removal Program	1 yr
Comments	Approximately 50% crown dieback due overshadowing. Crown bias northeast. Crown lift to 3 metres required.



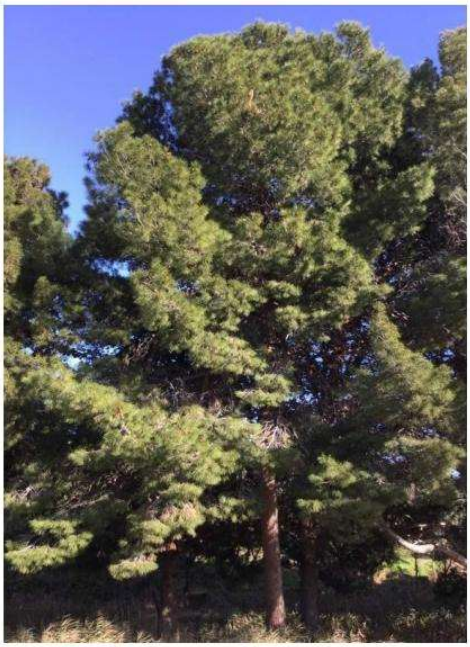
Tree ID	**8**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	2.26m
Removal Program	4 yr
Comments	Crown bias towards the northeast. Broad spreading. 30% crown dieback due to overshadowing. Used as swing. Remove lower southeastern dead lateral to main branching framework.



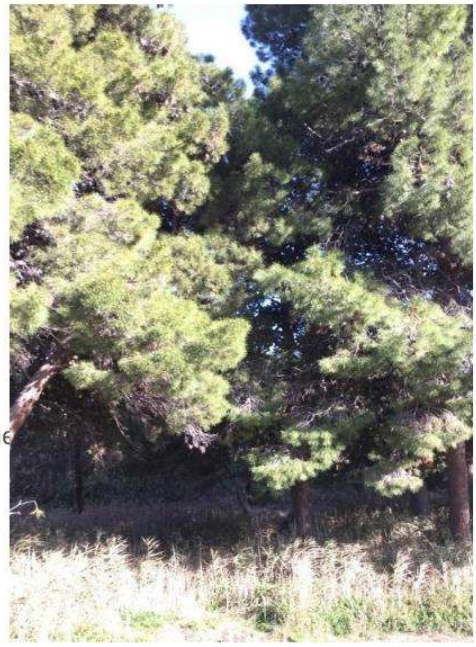
Tree ID	**9**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.96m
Removal Program	4 yr
Comments	Approximately 40% dieback by overshadowing. Crown lift to 3 metres. Crown bias south.



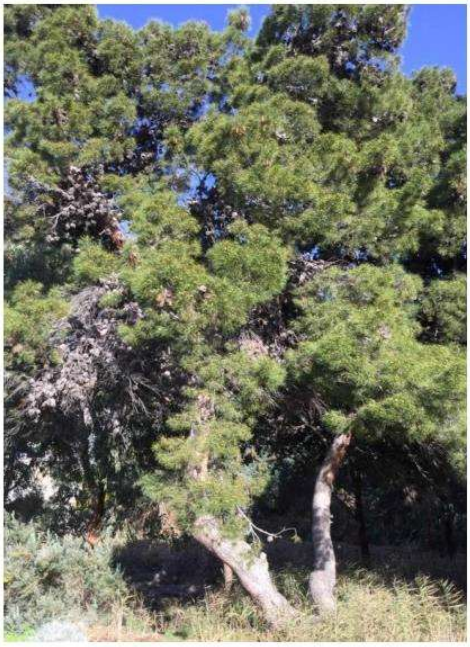
Tree ID	**10**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.45m
Removal Program	3 yr
Comments	Approximately 50% overall crown is dead southern side due to overshadowing. Crown bias towards northeast. Minor history of branch failure.



Tree ID	**11**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.89m
Removal Program	3 yr
Comments	Approximately 50% crown dieback, northe Crown lift to 3 metres.

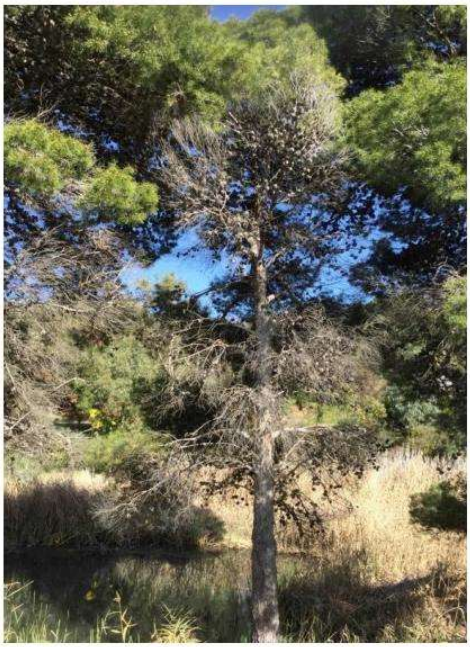


Tree ID	**12**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Poor
Circumference	1.51, & 1.45 m
Removal Program	1 yr
Comments	Poor form 50% crown dieback.



Tree ID	**13**
Species	Pinus halepensis
Height	10-20m
Health	Good
Structure	Good
Circumference	1.36m
Removal Program	5 yr
Comments	Moderate volumes of dead wood inner crown. Crown lift to 3 metres all sides.

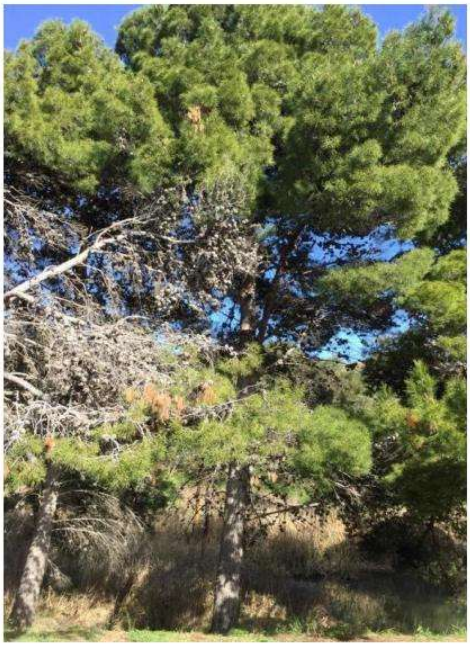
Tree ID	**14**
Species	Pinus halepensis
Height	10-20m
Health	Poor
Structure	Fair
Circumference	1.32m
Removal Program	1 yr
Comments	80% overall crown is dead.



Tree ID	**15**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Poor
Circumference	1.33m
Removal Program	1 yr
Comments	Twin leader poor form, 30% overall crown dieback.

Tree ID	**16**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.66m
Removal Program	4 yr
Comments	Crown lift to 3 metres. Crown bias towards the west.

Tree ID	**17**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.66m
Removal Program	3 yr
Comments	Poor form, no canopy 3/4 trunk northeastern side. Crown lift 3 metres.



Tree ID	**18**
Species	Pinus halepensis
Height	10-20m
Health	Poor
Structure	Poor
Circumference	1.55m
Removal Program	1 yr
Comments	Tall upright form no canopy majority of the northeastern side. poor tree

Tree ID	**19**
Species	Pinus halepensis
Height	10-20m
Health	Poor
Structure	Poor
Circumference	2.14m
Removal Program	1 yr
Comments	Approximately 50% crown dieback, poor form crown bias west, heavily pruned in past.

Tree ID	**20**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.65m
Removal Program	3 yr
Comments	Approximately 40% dieback northeastern side due to overshadowing. Crown lift to 3 metres.

Tree ID	**21**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Poor
Circumference	1.7m
Removal Program	2 yr
Comments	Approximately 50% of overall crown dieback. Trunk leans towards the southwest.

Tree ID	**22**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	3.18m
Removal Program	5 yr
Comments	Entire lower crown approximately 50% dead. Prune lower dead branches to 5 metres.

Tree ID	**23**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Poor
Circumference	1.83m
Removal Program	2 yr
Comments	Approximately 50% overall crown is dead due to overshadowing.

Tree ID	**24**
Species	Pinus halepensis
Height	10-20m
Health	Poor
Structure	Fair
Circumference	1.8m
Removal Program	2 yr
Comments	Approximately 60% overall crown is dead due to overshadowing. Crown bias towards the southeast.

Tree ID	**25**
Species	Pinus halepensis
Height	5-10m
Health	Poor
Structure	Poor
Circumference	0.65m
Removal Program	1 yr
Comments	Only a tuff of foliage end of trunk.

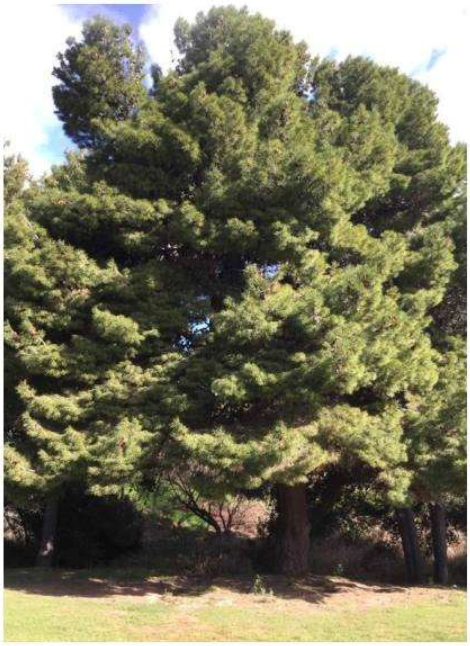
Tree ID	**27**
Species	Pinus halepensis
Height	5-10m
Health	Poor
Structure	Poor
Circumference	1.2m
Removal Program	1 yr
Comments	Approximately 80% overall crown is dead, crown bias towards southwest. Stunted growth.

Tree ID	**28**
Species	Pinus halepensis
Height	5-10m
Health	Poor
Structure	Poor
Circumference	1.25m
Removal Program	1 yr
Comments	Poor form 80% overall crown is dead. Crown bias towards the southwest.

Tree ID	**29**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.36m
Removal Program	2 yr
Comments	Upright crown, approximately 50% crown dieback.

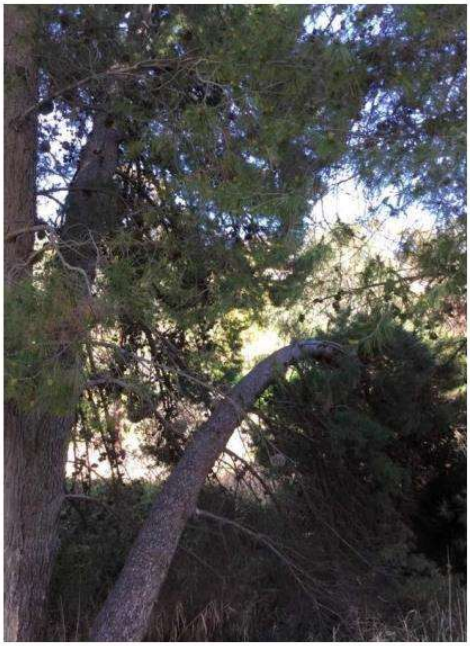
Tree ID	**30**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.23m
Removal Program	2 yr
Comments	Crown bias towards the southeast 50% overall crown is dead.

Tree ID	**31**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	3.83m
Removal Program	6 yr
Comments	Largest tree, moderate volumes of dead wood inner crown. Crown lift to 3 metres all sides.



Tree ID	**32**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.95m
Removal Program	3 yr
Comments	Some deadwood inner crown, crown lift 3 metres

Tree ID	**33**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Poor
Circumference	1.95, 1.32m
Removal Program	1 yr
Comments	Heavy bias to west, in contact with creek, bifurcation primary union.



Tree ID	**34**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.45m
Removal Program	2 yr
Comments	Crown dieback southern southwestern sides approximately 50%.

Tree ID	**35**
Species	Pinus halepensis
Height	10-20m
Health	Fair
Structure	Fair
Circumference	1.93m
Removal Program	2 yr
Comments	Approximately 50% crown dieback western side, removed earlier due to prevailing winds.

Appendix 2: Revegetation plan

Pre-European vegetation mapping[63] shows that the Cormorant Drive Reserve is predicted to have previously been *Olearia axillaris ± Leucopogon parviflorus* shrubland towards the coast, backing onto *Eucalyptus porosa ± Allocasuarina verticillata ± Melaleuca lanceolata* Low Woodland. However, it is considered that the riparian sections of the Reserve would formerly have been *Eucalyptus camaldulensis var. camaldulensis* Woodland over an open understorey of sedges, rushes, grasses and herbs, which is mapped along nearby upstream sections of the Field River. Current revegetation in riparian zones has focussed upon planting Red Gums (*Eucalyptus camaldulensis var. camadulensis*) as the dominant overstorey tree species. Figure A2.1 shows Red Gums on the creekline, estimated to be of approximately ten to fifteen years of age.

The plan for pine removal is shown in Figure A2.2. This revegetation plan is made to work in conjunction with Pine removal. The intent is to create 3 habitats:

1. A **creekline** habitat, dominated by Common Reed (*Phragmites australis*) and Narrow-leaf Bulrush (*Typha domingensis*), with an emergent shrub layer, particularly along edges, of Silky Tea-tree (*Leptospermum lanigerum*). This type of habitat will be suitable for feeding and perching for bird species such as the Little Grass Bird (*Megalurus gramineus*) and Australian Reed Warbler (*Acrocephalus australis*).
2. An edge of river **riparian** zone, of open Red Gum (*Eucalyptus camaldulensis var. camaldulensis*), over a generally open shrub and grassy/herbaceous understorey. It is also recommended that a stand of Swamp Paperbark (*Melaleuca halmaturorum*) is planted towards the northern end of the area assessed (to the west of trees marked 1-4 Figure A2.1) in year 1 to grow and potentially provide dense habitat that would be suitable for the Nankeen Night Heron in the future. The area of Swamp Paperbark at the mouth of the Field River is likely to currently provide habitat suitable for this species.
3. A **woodland** on uphill slopes from the River, composed of an open (20-30% cover) overstorey of *Eucalyptus porosa, Allocasuarina verticillata* over an open shrub understorey.

Table A2.1 provides a suggested list of species and planting densities for each of the different zones. Figure A2.3 provides an indicative map of the revegetation zones in the area impacted by pines. Note that this revegetation plan is indicative at this stage – finalisation of the plan would be recommended to include consultation with the Friends of Field River. It only covers the extent of the area where Aleppo Pines are being removed, but could be extrapolated to broader scale for the site more broadly if required.

[63] As per www.naturemaps.sa.gov.au accessed 10/9/20

Figure A2.1: Red gums along the Field River (circled), estimated to be approximately 10-15 years of age

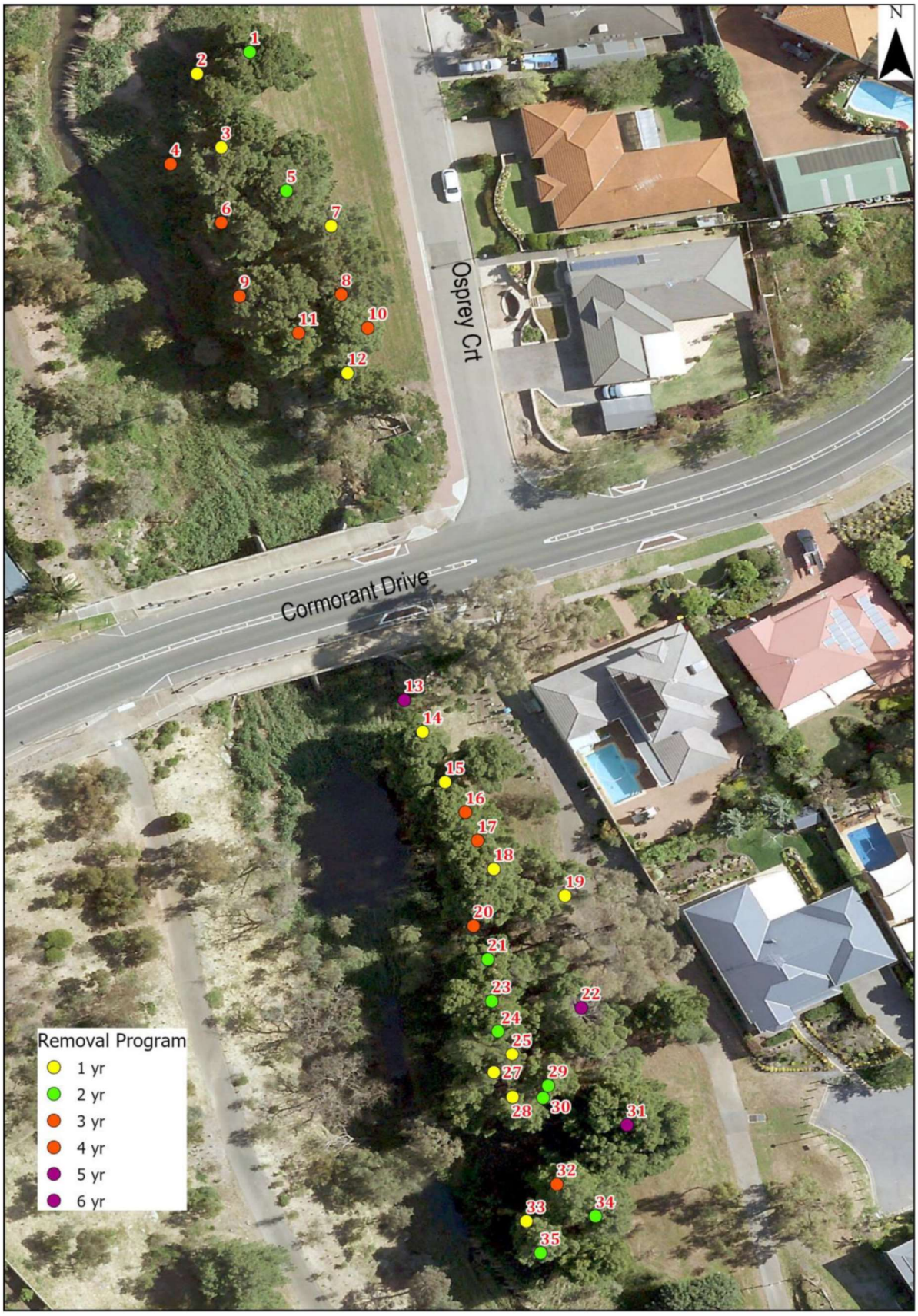


Figure A2.2: Proposed removal program for Aleppo Pines in Cormorant Drive Reserve

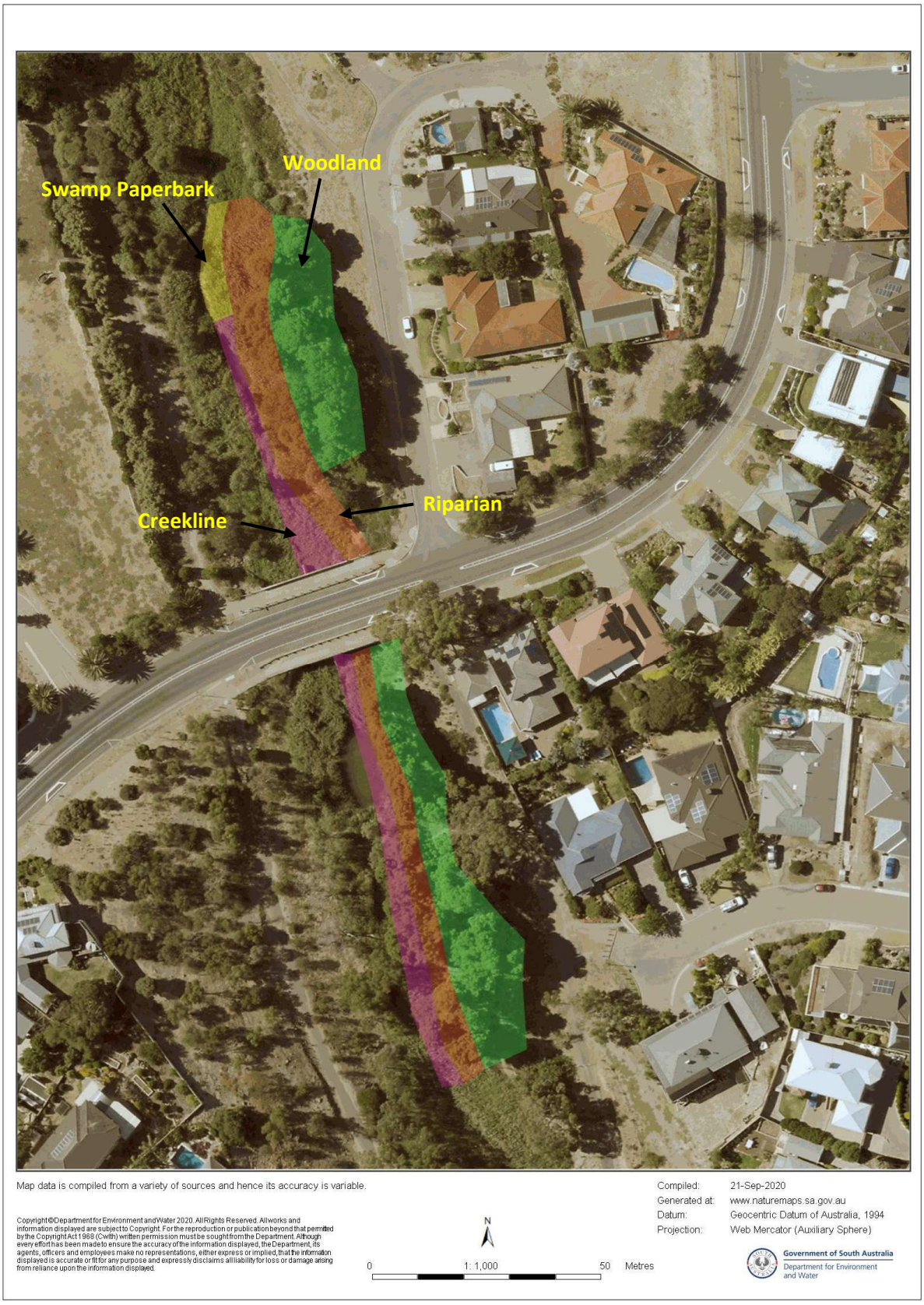


Figure A2.3: Revegetation zones in Cormorant Drive Reserve

Species	Common Name	Lifeform	Planting Density	Zone	Notes
Acacia acinacea	Wreath Wattle	Medium shrub	Sparse	W	
Acacia pycnantha	Golden Wattle	Small tree	Very sparse	W	
Allocasuarina verticillata	Drooping Sheoak	Small tree	Very sparse	W	
Arthropodium strictum	Common Vanilla-lily	Forb	Moderate	W	
Atriplex paludosa ssp. cordata	Marsh Saltbush	Low shrub	Sparse	R	Plant along edges of Field River
Austrostipa elegantissima	Feather Spear-grass	Tall Grass	Moderate	W	
Banksia marginata	Silver Banksia	Small tree	Sparse	R	In moist, damp areas following pine removal. This area may be marginal for this species, but it is a potential food plant for the Yellow-tailed Black Cockatoo.
Bulbine bulbosa	Bulbine-lily	Forb	Moderate	W	
Bursaria spinosa ssp. spinosa	Sweet Bursaria	Tall shrub	Sparse	W	
Calostemma purpureum	Pink Garland-lily	Forb	Moderate	W	
Cyperus vaginatus	Stiff Flat-sedge	Sedge	Moderate	R	Plant along edges of Field River
Dianella revoluta var. revoluta	Black-anther Flax-lily	Lily/sedge	Sparse	W	
Enchylaena tomentosa var. tomentosa	Ruby Saltbush	Low shrub	Sparse	W	
Eucalyptus camaldulensis ssp. camaldulensis	River Red Gum	Tall tree	Very sparse	R	Plant in open areas after pine removal, but be careful not to plant too densely - the long term aim is one tree per 200-300 square metres, or about 30-40 trees per hectare. Initial plantings can be at higher densities, to buffer against losses due to weather conditions etc.
Eucalyptus porosa	Mallee Box	Medium tree	Very sparse	W	
Eutaxia microphylla	Common Eutaxia	Low shrub	Sparse	W	
Hakea rostrata	Beaked Hakea	Medium shrub	Sparse	W	
Hakea rugosa	Dwarf Hakea	Low shrub	Sparse	W	
Kennedia prostrata	Scarlet Runner	Mat plant	Sparse	W	
Leptospermum lanigerum	Silky Tea-tree	Medium shrub	Sparse	C, R	Plant along edges and into margins of Field River.
Lomandra densiflora	Soft Tussock Mat-rush	Lily/sedge	Moderate	W	
Melaleuca halmaturorum	Swamp Paper-bark	Small tree	Dense patch	R	Plant year 1 in area near trees 1-2 to allow to form dense stand to provide habitat for Nankeen Night Heron. Track survival and re-plant as required to allow for a dense stand to form.
Melaleuca lanceolata	Dryland Tea-tree	Small tree	Very sparse	W	
Rytidosperma caespitosum	Common Wallaby-grass	Small grass	High	W	
Scaevola albida	Pale Fanflower	Mat plant	Sparse	W	
Themeda triandra	Kangaroo Grass	Tall grass	Moderate	W	

Vittadinia blackii	Narrow-leaf New Holland Daisy	Forb	Moderate	W	

Zone: C= in creekline vegetation, R = riparian zones along edge of creekline, W = woodland on upslopes from creekline.

Planting densities: Very sparse: <100 per hectare, Sparse < 200 per hectare, Moderate 200-500 per hectare, High 500-1000 per hectare. Note these are initial planting densities.