



SAVING OUR SPECIES

Corang pine (*Callitris oblonga* subsp. *corangensis*)

2023 post-fire survey, Corang River



Acknowledgement of Country

The Department of Planning and Environment acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

© 2023 State of NSW and Department of Planning and Environment

With the exception of photographs, the State of NSW and Department of Planning and Environment (the department) are pleased to allow this material to be reproduced in whole or in part for educational and non-commercial use, provided the meaning is unchanged and its source, publisher and authorship are acknowledged. Specific permission is required to reproduce photographs.

Learn more about our copyright and disclaimer at www.environment.nsw.gov.au/copyright

Acknowledgements

Thanks to South East Local Land Services, Braidwood staff, particularly Andrew Taylor, for assistance in contacting local landholders. Thanks to Louis Munnings for his invaluable assistance with fieldwork and to Roger Farrow for his entomological advice, identifying the insect responsible for impacting post-fire Corang pine seedling recruits.

The significant contribution that the local landholders make to the conservation and protection of this species is acknowledged. Without their ongoing support the Corang pine populations would be under much greater threat. Many thanks to those landholders who allowed access, helped with survey, collected and propagated seed, and for their enthusiastic involvement in the recovery of this iconic local species.

Report prepared by: Mary Appleby¹, Genevieve Wright² and Nick Munnings¹

¹ Contract ecologist

² Department of Planning and Environment, Biodiversity and Conservation, South East Branch

Cover photo: Corang pine juvenile with fruit, 2023.
Mary Appleby/DPE

Published by:

Environment and Heritage Group

Department of Planning and Environment

Locked Bag 5022, Parramatta NSW 2124

Phone: +61 2 9995 5000 (switchboard)

Phone: 1300 361 967 (Environment and Heritage enquiries)

TTY users: phone 133 677, then ask for 1300 361 967

Speak and listen users: phone 1300 555 727, then ask for 1300 361 967

Email: info@environment.nsw.gov.au

Website: www.environment.nsw.gov.au

ISBN 978-1-923132-21-4

EHG 2023/0349

October 2023

Find out more at:

[environment.nsw.gov.au](http://www.environment.nsw.gov.au)



Contents

Contents	iii
Executive summary	v
1. Background	1
2. Purpose	4
3. Survey details	5
4. Results	8
4.1 Survey results	8
4.2 Ecological observations	11
5. Discussion	26
6. Recommendations	29
7. References	30

List of images

Image 1	<i>Callitris oblonga</i> , male cones on seedling recruit, 2 years post-fire	v
Image 2	Corang pine habitat, 2019–20 high severity fire impacts	1
Image 3	Surviving unburnt Corang pines with post-fire regeneration in foreground	2
Image 4	Stems of burnt Corang pine adult with seedling recruitment	4
Image 5	Dead Corang pine tree (readily identified by persistent cones) and post-fire regrowth	5
Image 6	Harvesting seed from recently windthrown Corang pine	11
Image 7	Typical habitat of Corang pine along the Corang River	12
Image 8	Dense Corang pine seedlings in slashed firebreak south of Nerriga Bridge travelling stock reserve (TSR)	12
Image 9	Dense post-fire regrowth. Corang pine is absent in these areas	13
Image 10	Corang pine is present in swampy foreground but absent from button grass (<i>Gymnoschoenus sphaerocephalus</i>) swamps above	13
Image 11	Even-aged post-fire recruitment of Corang pine and associated species	14
Image 12	Range of Corang pine post-fire seedling sizes, Nerriga Bridge TSR	15
Image 13	Sparse recruitment (white circles) of Corang pine in a severely burnt site and seedling of <i>Isopogon anethifolius</i> (black circle)	16

Image 14	Adult Corang pine that had been alive in the 2020–21 survey and had subsequently died	17
Image 15	Juvenile Corang pine with female and smaller (<2 mm) male cones (white arrow)	18
Image 16	Female cones on juvenile Corang pine	18
Image 17	Corang pine post-fire seedling recruits, browsing impact of <i>Callitris</i> sawfly larvae	19
Image 18	Larva of <i>Callitris</i> sawfly <i>Zenarge turneri turneri</i> on Corang pine	20
Image 19	Close-up of larva of <i>Callitris</i> sawfly <i>Zenarge turneri turneri</i>	20
Image 20	Bark-stripping by yellow-tailed black cockatoos	21
Image 21	Rabbit scats among Corang pine seedlings	22
Image 22	Flood debris containing dead Corang pine (Corang pine fruit seen in white oval)	23
Image 23	Endangered dwarf kerrawang (<i>Commersonia prostrata</i>)	24
Image 24	Patch of dead Corang pine juveniles beneath radiata pine (in white circle)	25
Image 25	Corang pine seedlings	27

List of figures

Figure 1	Numbers of Corang pine found, by age class, 2020–21 survey	10
Figure 2	Numbers of Corang pine found, by age class, 2023 survey (plot data only)	10

List of maps

Map 1	Distribution of the 3 subspecies of <i>Callitris oblonga</i>	3
Map 2	Corang pine survey extent, 2023	7
Map 3	2023 distribution of live and dead Corang pine	9

Executive summary

The Corang pine (*Callitris oblonga* subsp. *corangensis*) is a threatened plant that is only known from a 24 km stretch of the Corang River, north of the town of Braidwood in the NSW southern tablelands. It is a small coniferous tree or shrub that grows to 6 m tall and occurs primarily in the riparian zone. The Corang pine is currently a site-managed species in the NSW Government's Saving our Species (SoS) program, and the current survey was funded through this program.

The 2019–20 wildfires burnt large areas of this species' habitat. A 2020–21 post-fire survey found that only 2% of the adult population (69 adult plants) had survived the fire (Appleby and Wright 2021). There was extensive seedling establishment of the Corang pine immediately after the fire with over 76,000 seedlings counted in burnt areas.

The 2023 survey, documented here, assessed the status of the Corang pine 3 years after the significant impact of the 2019–20 wildfires. Survey results of the current population are a total of 89 live seed-bearing adults, 3,573 juveniles and 1,118 seedlings. A number of threats were recorded for the species including impacts from weeds, floods, browsing and land clearing.

With only 89 mature plants counted in this survey, patchy recruitment, browsing pressure, weed competition and predicted climate change impacts (increased drought, floods, severe weather events and fire danger days) it is considered that the entire subspecies remains extremely vulnerable in the short term and requires long-term monitoring to assess its recovery and threat management requirements.



Image 1 *Callitris oblonga*, male cones on seedling recruit, 2 years post-fire

Image: G Wright/DPE, 30 September 2022

1. Background

The cypress pine (*Callitris oblonga*) is a small coniferous tree or shrub that grows to 6 m tall. It is regarded as a relict species, having survived the last ice age in small, widely dispersed populations along waterways (Nadolny and Benson 1993). *Callitris oblonga* occurs from the northern tablelands of New South Wales to north of Hobart in Tasmania. Within this large area it has small, locally restricted, sporadic populations that are morphologically distinguishable and recognised as 3 distinct subspecies (Hill 1998). It has 2 subspecies in New South Wales and one in Tasmania (Map 1). In Tasmania the subspecies *oblonga* is confined to the south-east of the state; in New South Wales subspecies *parva* occurs at a number of sites on the eastern edge of the New England Tablelands (NPWS 2001). Subspecies *corangensis* is only known to occur in the Corang River catchment, mostly confined to the banks and surrounds of the Corang River.

The 2019–20 wildfires burnt large areas of habitat of both subspecies that occur in New South Wales (Appleby and Wright 2021; DPIE 2020). This report focuses only on the southern subspecies *corangensis*, which experienced high fire severity within its habitat (Image 2).



Image 2 Corang pine habitat, 2019–20 high severity fire impacts
Image: M Appleby/DPE, November 2020

The Corang pine is known to be sensitive to high severity fire, with plants killed by 100% scorch. Frequent fire is regarded as a threat to this species, with the recommended minimum fire interval being >7 years (NPWS 2001). The species has a serotinous response to stochastic events such as fire and flood through the mass release of seed from cones held in the tree canopy. Seed is released following death of individual limbs or the entire tree (Nadolny and Benson 1993). Unlike other species of *Callitris*, which have fairly continuous recruitment, *Callitris oblonga* appears to be dependent on disturbance events such as flood and fire to trigger seed drop and germination (Harris and Kirkpatrick 1991). Recruitment of burnt populations is reported to be dependent on post-fire rainfall to trigger and promote germination (NPWS 2001).

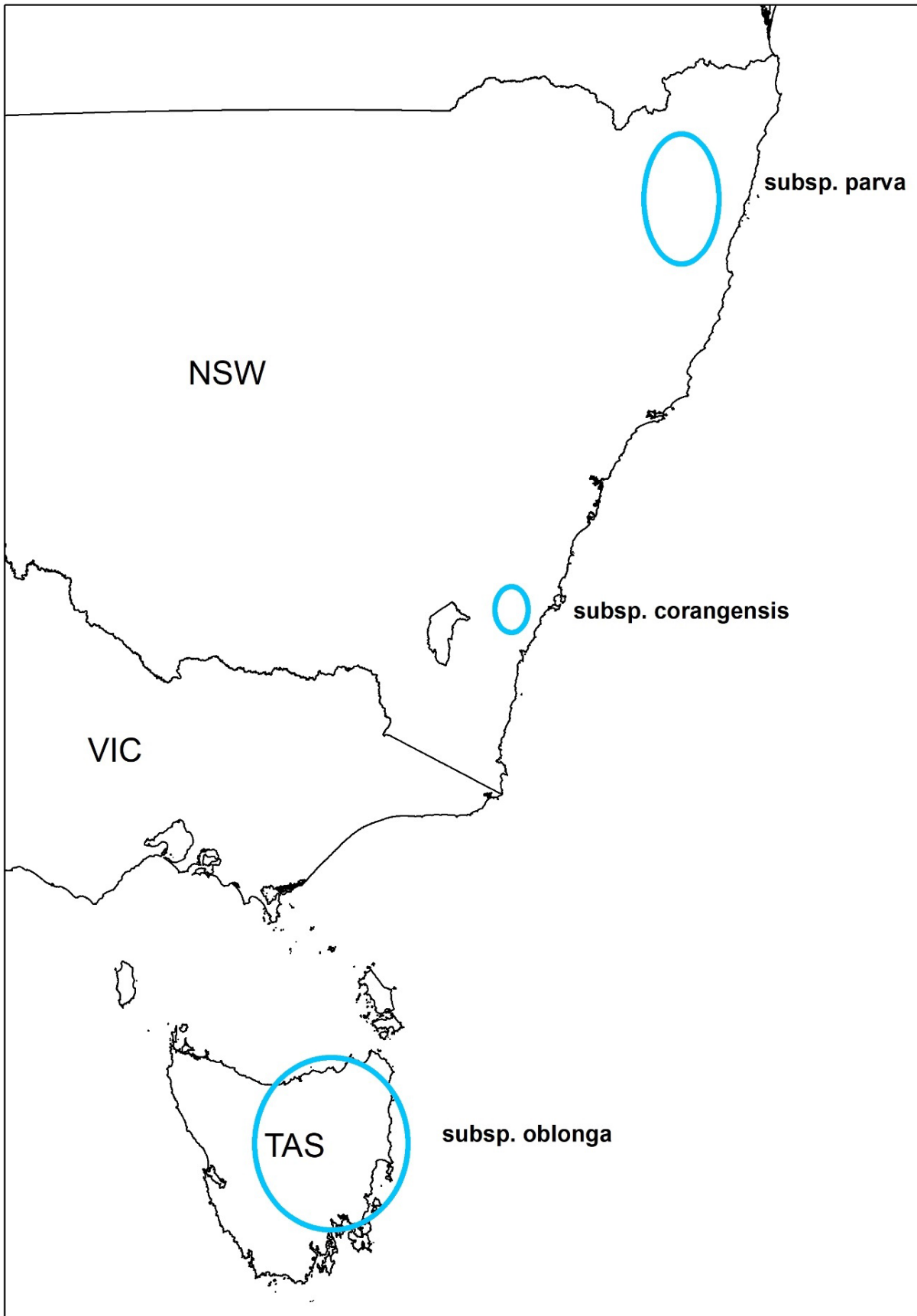
The 2019–20 wildfires impacted an estimated 83% of the Corang pine population. A post-fire survey conducted between late November 2020 and early May 2021 found that only around 2% of the adult population had survived the fire (Appleby and Wright 2021). While there was significant post-fire seedling recruitment, several major floods impacted this post-fire response. The Corang pine is clearly adapted to flood-prone environments, however, these extreme flood events destroyed adult trees that had survived the fire, and removed soil, seed and possibly also seedlings in the impacted flood zone (Appleby and Wright 2021).

The Corang pine is listed (with the other NSW subspecies *parva*) as vulnerable under the NSW *Biodiversity Conservation Act 2016*. Subspecies *corangensis* has recently been listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is also listed on the *Final list of plants requiring urgent management intervention* developed in response to the 2019–20 fires by the Wildlife and Threatened Species Bushfire Recovery Expert Panel (Gallagher 2020). The Expert Panel considered this subspecies at particular risk due to the interactive effects of the 2019–20 fire and the prolonged drought that preceded it.



Image 3 Surviving unburnt Corang pines with post-fire regeneration in foreground

Image: M Appleby/DPE, November 2020



Map 1 **Distribution of the 3 subspecies of *Callitris oblonga***
Map: G Wright/DPE, September 2023

2. Purpose

The Corang pine is currently a site-managed species in the SoS program. As part of that program, identified priority actions include monitoring of species abundance, extent and condition and threat assessment to inform management actions. A critical action identified for this species was the assessment of the impact of the 2019–20 wildfires.

The objectives of the current survey were to:

- repeat the post-fire survey conducted in 2020–21 to determine any changes to the population size and status
- assess seedling survival and ongoing recruitment
- assess recruitment in areas of high fire severity
- identify current and potential threats
- record observations regarding the ecology of the species
- collect seed if available and lodge in the seed bank at the Australian Botanic Garden, Mount Annan, New South Wales.



Image 4 **Stems of burnt Corang pine adult with seedling recruitment**

Image: M Appleby/DPE, April 2023

3. Survey details

Field surveys were conducted between late March and early May 2023 along the Corang River between the localities of Oallen and Wog Wog. Survey commenced 700 m upstream of the confluence of the Corang River and Nadgengutta Creek and ended at the falls below Corang Lagoon on a section of river bounded on one side by Morton National Park (Map 1). Both sides of the river were traversed between these 2 locations where accessible. A distance of approximately 24 km was surveyed. As most of the Corang River is bounded by private land, landholders were contacted through South East Local Land Services to gain road access where possible. Some sites were only accessible via the river in kayaks, and the survey was limited to counts of visible dead/living adult trees where the bank was not accessible. Some sections of river were not surveyed because permission for access was not granted in time for survey commencement.

The purpose of the 2023 program was to (i) locate and survey all the sites where data were collected in 2020–21, (ii) survey areas in between these sites, and (iii) survey new areas (upstream of the previous survey limit) to determine the southern extent of the population. In 2020–21, data recorded included the presence and number of seedling recruits, juvenile plants, live and dead adults, as well as observations of local fire intensity and impacts (Appleby and Wright 2021). The survey methodology utilised in 2020–21 was patch, rather than plot based, with counts and/or estimates completed within different sized areas determined by local site variability.



Image 5 Dead Corang pine tree (readily identified by persistent cones) and post-fire regrowth

Image: M Appleby/DPE, 2023

3.1 Survey methodology 2023

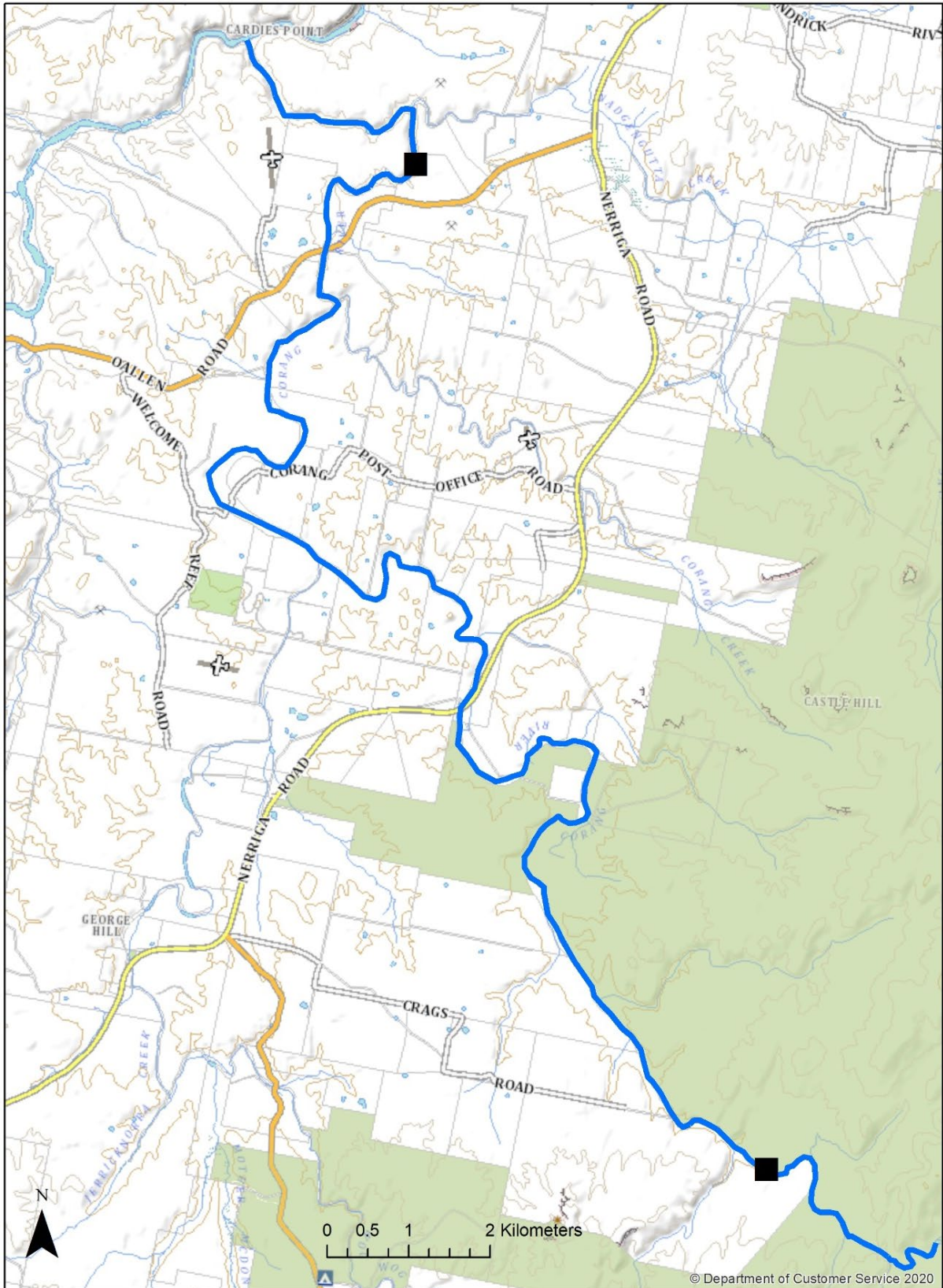
In 2023 data collection utilised 2 methods: plot sampling and site-based sampling. Plot sampling was used at each of the 2020–21 surveyed sites that were relocated, and data collected within 10 m x 10 m plots at each of these locations. If a standard 10 m x 10 m plot was not possible due to site barriers such as fence lines, cliffs or watercourses, the actual dimensions of each non-standard plot was recorded. Data collected at each site included: GPS location, fire severity, age classes and counts within each class, post-fire mortality, threats and general ecological observations. Where patches were large and time allowed, 10 m x 10 m plots were also sampled within new sites.

Site-based sampling was a quicker method used to assess (i) new sites (areas that were not surveyed in 2020–21) or (ii) 2020–21 records that could not be located with enough certainty. Data collected included the beginning and end points of patches of Corang pine, fire severity, threats, estimated numbers of live plants within each age class and trees killed in the 2019–20 fires. To enable rapid assessment of as many new sites as possible, actual counts of individuals within age classes or dead trees were not made.

New sites were mainly identified by the presence of dead adult plants with distinctive cones still visible (Image 5). All sites were photographed and geo-referenced to enable future monitoring.

Where possible, seed was collected from live adult trees throughout the extent of the surveyed population. In some cases, trees were in poor health and/or infested with *Callitris* sawfly larvae (*Zenarge* sp.; Moore 1963; R Farrow pers. comm.); seed was not collected from these individuals. Cones were also not collected from post-fire recruits, which had just produced their first fruit and judged to be insufficiently robust to be harvested. These plants were generally only 300–450 mm tall and all had fewer than 10 cones, many of which were already predated by yellow-tailed black cockatoos.

Not all of the 163 sites surveyed in 2020–21 could be found in 2023, with a small number (14) unable to be relocated. The post-fire landscape in 2023 was very different to that encountered in 2020–21. Dense post-fire regeneration of associated vegetation made walking and observations more difficult than had been the case in the denuded landscape immediately post-fire. Several further severe flood events had resulted in dead adult plants being washed away (Image 22), which meant that some 2020–21 sites could not be easily or accurately relocated.



 Morton National Park  Corang River  2023 survey start / end

Map 2 **Corang pine survey extent, 2023**
Map: G Wright/DPE, July 2023

4. Results

4.1 Survey results

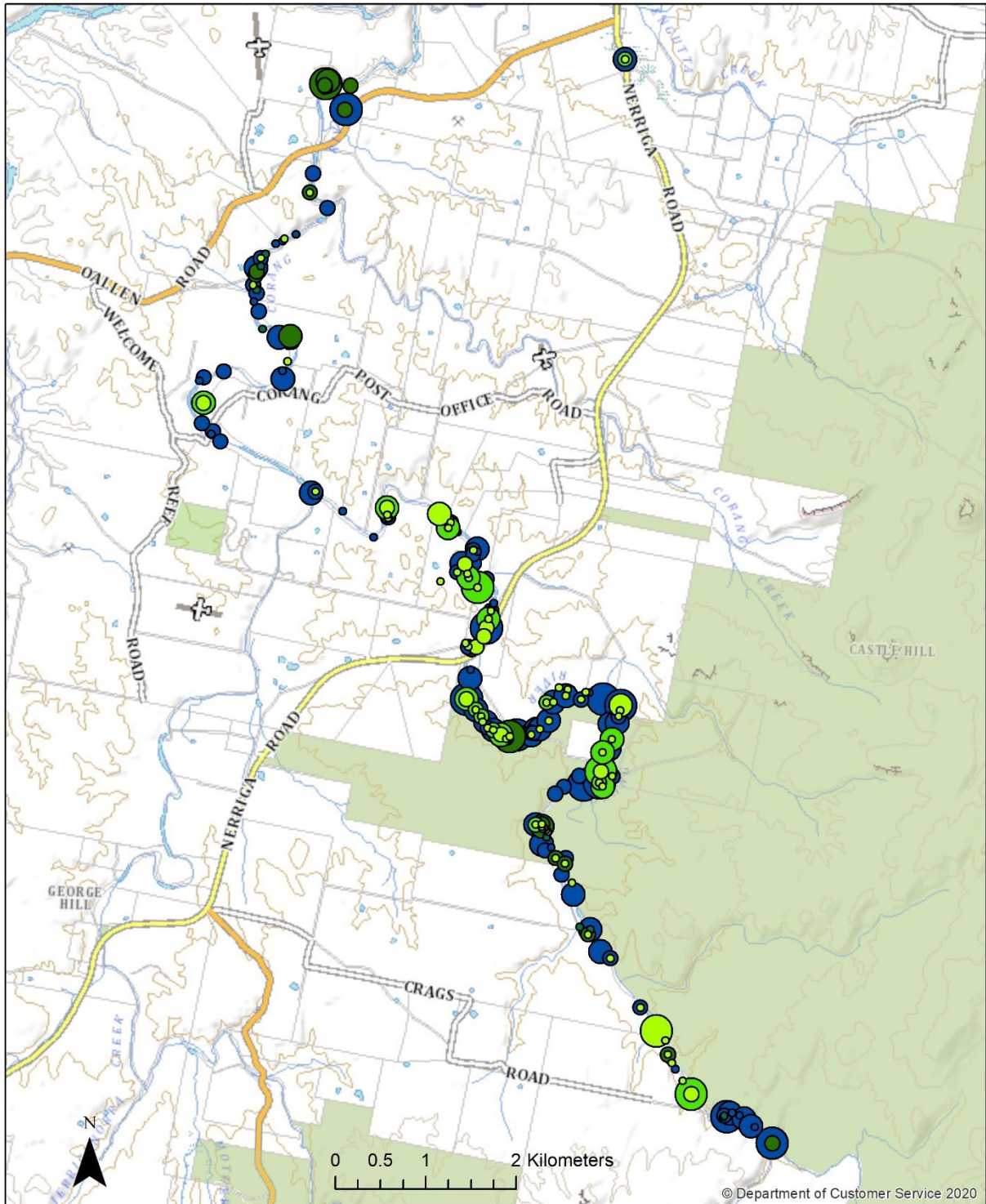
The 2023 survey covered 24 km of the Corang River, between the Nadgengutta Creek confluence and the falls upstream of Goodsell Creek and one site near the intersection of Nerriga Road and Oallen Road (Map 2). A total of 189 sites were surveyed (80 sites plot-sampled, 109 site-based sampled).

Eighty-nine live adults were recorded during the survey, all in unburnt patches; this number represents the total number of live adult plants found. There were 1,118 seedlings recorded (juvenile foliage present, <100 mm height), 3,573 juveniles (woody specimens <1 m) and 968 dead plants (Figure 2). Ten of these dead adult plants were live seed-bearing plants in 2020–21. Two plants were most likely destroyed as a result of grading in a site near the Corang Post Office Road crossing, one had recently succumbed to storm damage, one had died due to its root system being exposed from severe flood scouring. The cause of death of the remaining 6 plants within 4 of the sites is unknown.

During the 2020–21 surveys, post-fire recovery data were collected at 163 sites. In 2023, 26 of these were not surveyed due to access constraints. Of the remaining 137 sites, 88 had plants present, 49 had no plants.

Of the 189 sites surveyed in 2023, 52 were new sites. Ten of these were in a range extension south of Smilers Creek (the previous known limit of the species) to the falls above Goodsell Creek. Twenty-three sites had only dead standing adults present with no seedling recruitment. The recorded occurrences of dead *Callitris* (Map 3), indicate the original distribution of the species occupied much of the stretch of river surveyed. The gaps in distribution were upstream of Corang Post Office Road, and upstream of Oallen Road. Both of these areas are heavily planted with radiata pine (*Pinus radiata*). The greatest concentration of Corang pines occurs in the middle stretch of the river, around Kings Flat and in the vicinity of Nerriga Road Bridge (Map 3). Post-fire recruitment is sparse downstream of Fernbrook Road (roughly equidistant between Nerriga Road and Corang Post Office Road).

Direct comparison of plant numbers between the immediate post-fire patch-based 2020–21 survey and the present survey, which utilised both plot counts and site-based sampling, is not possible. The only comparison that can be made is the total counts completed divided into age class. Figures 1 and 2 show the population structure immediately post-fire (2020–21 survey) and 3 years after fire (2023 survey).



Seedlings

- 1 - 17
- 18 - 56
- 57 - 122
- 123 - 230

Juveniles

- 1 - 18
- 19 - 46
- 47 - 115
- 116 - 418

Adult

- 1
- 2 - 3
- 4 - 6
- 7 - 11

Dead

- 1 - 2
- 3 - 8
- 9 - 16
- 17 - 30

Map 3 2023 distribution of live and dead Corang pine

Map: G Wright/DPE, July 2023

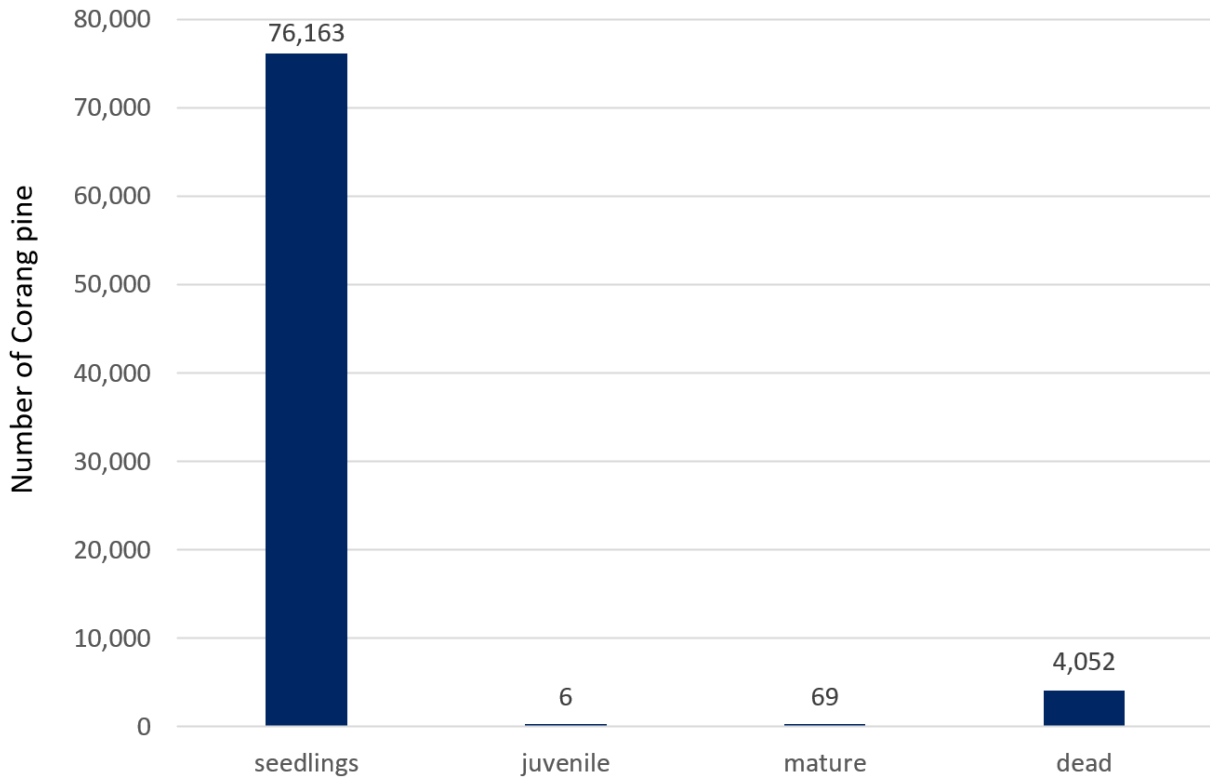


Figure 1 Numbers of Corang pine found, by age class, 2020–21 survey

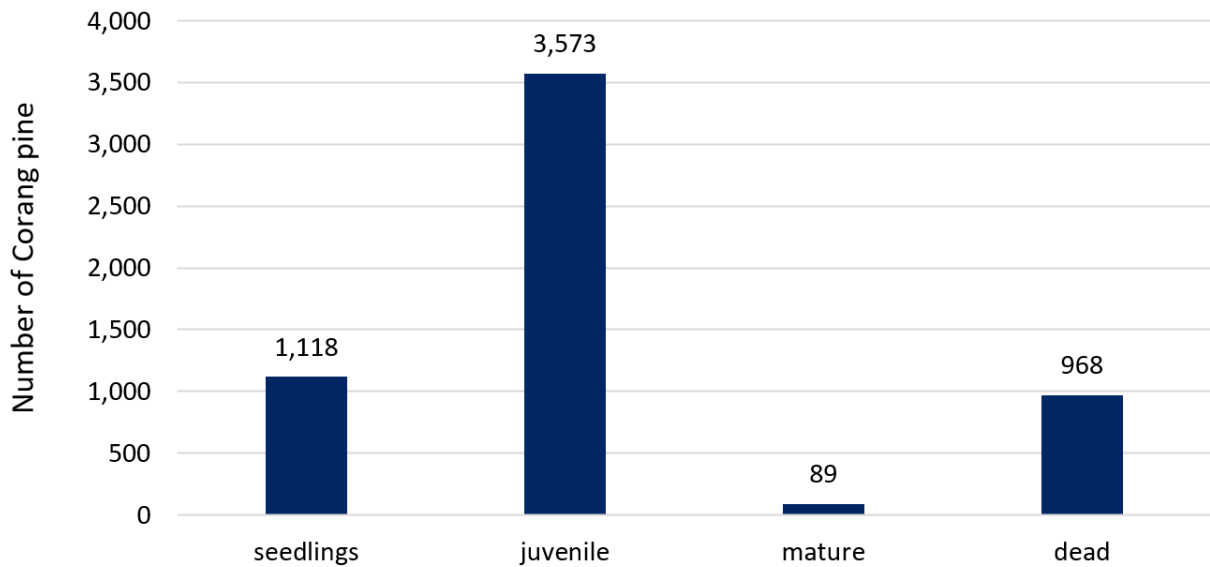


Figure 2 Numbers of Corang pine found, by age class, 2023 survey (plot data only)

The 10 sites where fire intensity destroyed both the crown layer and the humic layer in the soil (noted in the 2020–21 survey) were resurveyed in 2023 (Image 13). There was poor survival in the intervening 2 years (seedling numbers from 0–10; juveniles 0–92 (mean=16.6) in 10 m x 10 m quadrats). The plot with 92 juveniles was part of a site with massive recruitment noted in 2021 – an estimated 10,000 seedlings in the whole patch.

Cones were harvested from 16 sites from healthy, mature living plants for seed banking at Mt Annan Botanic Gardens. As some previously harvested trees had subsequently died from unknown causes, trees in poor health were not targeted for seed collection. Secateurs used for seed collection were sterilised with methylated spirits to minimise potential spread of pathogens between plants.



Image 6 Harvesting seed from recently windthrown Corang pine

Image: M Appleby/DPE, 2023

4.2 Ecological observations

4.2.1 Habitat

Corang pine occurs along a 24 km section of the Corang River and at one isolated site 3 km east of the northern extent of the species (Map 2). It generally occurs in sandy soils on sandstone in riparian vegetation dominated by ribbon gum (*Eucalyptus viminalis*), *Hakea eriantha*, black she-oak (*Allocasuarina littoralis*), sweet bursaria (*Bursaria spinosa*), tautoon (*Leptospermum polygalifolium*), river bottlebrush (*Callistemon sieberi*) and river lomatia (*Lomatia myricoides*) (Image 7). It coexists within the margins of extensive radiata pine plantations that occur along the river. Most of the population is within 50 m of the river's edge. It also occurs on old rocky riverbeds or instream islands. Sites found further from the current riverbank usually represent historic riverbeds. The species is less common on steep, rocky sites. Corang pine is also found in areas with shale or quartzite derived soils. It is particularly prolific in areas with deeper alluvial soil (e.g. Kings Flat). It occurs in intermittently swampy areas close to the river, but not in hanging *Gymnoschoenus* swamps, which occur in the upper reaches (Image 10). In the upper catchment, Corang pine is associated with rainforest margin species eastern leatherwood (*Eucryphia moorei*) and Monga waratah (*Telopea mungaensis*). Corang pine was absent from areas with dense native *Acacia mearnsii*, *Cassinia longifolia* or very weedy regrowth, and appeared to favour more open sites (Image 9). Seedlings were prolific in areas slashed for hazard reduction or access (Image 8).



Image 7 Typical habitat of Corang pine along the Corang River

Image: M Appleby/DPE, 2023



Image 8 Dense Corang pine seedlings in slashed firebreak south of Nerriga Bridge travelling stock reserve (TSR)

Image: M Appleby/DPE, 2023



Image 9 Dense post-fire regrowth. Corang pine is absent in these areas
Image: M Appleby/DPE, 2023



Image 10 Corang pine is present in swampy foreground but absent from button grass (*Gymnoschoenus sphaerocephalus*) swamps above
Image: M Appleby/DPE, 2023

4.2.2 Fire response

As noted in previous studies (Harris and Kirkpatrick 1991; Nadolny and Benson 1993), *Callitris oblonga* is serotinous, responding to catastrophic events such as fire and flood with the mass release of seeds, re-establishing its populations through seedling recruitment. It is an obligate seeder and is fire-killed. This was confirmed during the 2023 surveys, with no resprouting observed and death of fire-affected individuals.

Harris and Kirkpatrick (1991), comparing *Callitris oblonga* with *Callitris rhomboidea*, noted that the former species did not regenerate without disturbance. This would suggest that recruitment would be even-aged following the 2020 fire (Image 11). While the vast majority of recruitment occurred within the first year after the fire, field observations revealed that there were subsequent small flushes of seedling emergence at many sites. Recruits at various stages of development (10 mm to 800 mm) occurred within the same patch, suggesting ongoing recruitment in the 3 years post-fire (Image 12). Some seed is retained within cones on dead plants and can be released after the main mass germination events following fire. This may explain the observed range in age of seedling recruits in the field. This observation has been noted in the northern subspecies *parva*, with small numbers of seeds retained in cones a year following fire (Nadolny and Benson 1993). Cones of burnt individuals of Corang pine were heavily predated by yellow-tailed black cockatoos (*Zanda funerea*) post-fire after the first flush of seedlings (Appleby and Wright 2021), also indicating some seed is retained following the main post-fire recruitment.

Seed release also occurs after limb death (Nadolny and Benson 1993). Small numbers of seedlings were also observed beneath recently dead individuals, plants that had survived fire and subsequently died (Image 14).



Image 11 Even-aged post-fire recruitment of Corang pine and associated species

Image: M Appleby/DPE, 2023



Image 12 Range of Corang pine post-fire seedling sizes, Nerriga Bridge TSR
Image: G Wright/DPE, March 2023



Image 13 Sparse recruitment (white circles) of Corang pine in a severely burnt site and seedling of *Isopogon anethifolius* (black circle)

Image: M Appleby/DPE, April 2023



Image 14 **Adult Corang pine that had been alive in the 2020–21 survey and had subsequently died**

The dead plant was an outlier in an unburnt area and had been observed by the landholder to decline gradually over 1–2 years post-fire. Image: M Appleby/DPE, April 2023

4.2.3 **Reproductive maturity**

The 2023 surveys recorded a small number of Corang pine with both male (Image 1) and female cones (Images 15 and 16). Within the Corang pine post-fire recruitment there were very few (<2%) that had reached reproductive maturity and there were many sites where no juvenile plants had started to produce fruit.



Image 15 Juvenile Corang pine with female and smaller (<2 mm) male cones (white arrow)

Image: M Appleby/DPE, April 2023



Image 16 Female cones on juvenile Corang pine

Image: M Appleby/DPE, April 2023

4.2.4 Browsing/predation

In September 2022, prior to the 2023 surveys, browsing impacts were observed on seedling recruits at Nerriga Bridge TSR (Image 17). This was thought to be caused by the larvae of the *Callitris* sawfly, *Zenarge turneri turneri*, which feeds on *Callitris* and other species of *Cupressaceae* in coastal and highland areas of New South Wales (Moore 1963). This was confirmed by Roger Farrow from larvae images taken in the field (Images 18 and 19). Most surviving adult trees and many juveniles showed some evidence of this insect browsing. *Callitris* sawfly larvae can cause complete defoliation of individual trees, with a preference for younger specimens (Moore 1963), although several mature trees had significant foliage loss due to insect attack. Larvae were observed on many juveniles and several adult plants. Some patches of live adults appeared unaffected; others showed recovery from sawfly infestation. Mature plants at one location near Nerriga, where considerable insect impact was noted in 2020, had either recently died or appeared unlikely to recover.

Moore (1963) noted that plant recovery was usual after a season, with decline in host plants more likely with sawfly larvae infestations in successive years, or when plants were growing in less favourable conditions.



Image 17 Corang pine post-fire seedling recruits, browsing impact of *Callitris* sawfly larvae

Image: G Wright/DPE, September 2022



Image 18 Larva of *Callitris* sawfly *Zenarge turneri turneri* on Corang pine
Image: M Appleby/DPE, April 2023



Image 19 Close-up of larva of *Callitris* sawfly *Zenarge turneri turneri*
Image: M Appleby/DPE, April 2023

Seed predation by yellow-tailed black cockatoos (*Zanda funerea*) was noted on both dead and living plants in both the 2020–21 (Appleby and Wright 2021) and 2023 surveys. This was widespread throughout the survey area, particularly in burnt areas, and affected both mature specimens and juveniles with recently developed female cones. Cockatoos had also stripped bark on some live plants (Image 20).



Image 20 **Bark-stripping by yellow-tailed black cockatoos**
Image: M Appleby/DPE, April 2023

Pig, rabbit, wombat and bandicoot activity had a minor impact on seedling survival through soil disturbance. Goat, rabbit and deer scats were also observed (Image 21), and skeletal remains of a goat. None of these animals appeared to have browsed the Corang pine, with no herbivore impacts evident.

Plants were briefly exposed to cattle at the TSR at Nerriga Road bridge. There appeared to be little impact on the survival of juvenile plants.



Image 21 Rabbit scats among Corang pine seedlings

Image: M Appleby/DPE, March 2023

4.2.5 Flooding

Distribution of all *Callitris oblonga* taxa is associated with waterways across its entire distribution, including ssp. *corangensis* (Nadolny and Benson 1993). Floods are an integral part of riparian environments and aid in the dispersal of Corang pine seed.

The occurrence of a major flood event following a prolonged drought and 6 weeks after the 2019–20 fire resulted in severe scouring along many sections of riverbank. This swept away both live and dead plants of Corang pine (Appleby and Wright 2021). During the 2023 surveys dead plants were often found amongst large piles of flood debris (Image 22). Several sites from the 2020–21 survey in which Corang pine was recorded, were searched and had no remaining dead adults or recruits. Flood impacts were recorded at many of these sites, and it was presumed plants had been removed by the flood. Floodwaters exacerbate the effect of intense fire damage to vegetation and soil. Four of the 10 most severely burnt sites also suffered significant flood damage, which reduced surviving seedling numbers.



Image 22 Flood debris containing dead Corang pine (Corang pine fruit seen in white oval)
Image: M Appleby/DPE, 2023

4.2.6 Competition/weeds

Significant weed cover (10–20% cover) was noted in only 10 of the surveyed sites. The most common weeds found included fleabanes (*Conyza* species), cat's-ear (*Hypochaeris radicata*), spear thistle (*Cirsium vulgare*), nightshade (*Solanum nigrum*) and sweet vernal grass (*Anthoxanthum odoratum*). Most of the widespread colonising species (natives *Einadia trigonos*, *Dysphania pumilio*, and weeds *Phytolacca octandra*, *Cirsium vulgare*) that appeared in large numbers immediately after the 2020 fire have now largely disappeared.

The dwarf kerrawang (*Commersonia prostrata*) is listed as endangered under both NSW and Commonwealth legislation. It is a sprawling herb and emerged in large numbers after the 2019–20 wildfire (Image 23). This species persists along most stretches of the Corang River but has disappeared from areas where shrub regrowth is dense. It appears to be a post-fire responder, with large increases after fire and widely fluctuating numbers observed over time (Carter and Walsh 2010). It has flowered and set seed since the 2019–20 fire, replenishing the seedbank. The species has been recorded from the area previously (a small population near the Corang River according to the species' NSW Threatened Species Profile (DPE 2023)) but has not been observed by one author (M Appleby pers. comm.) in several pre-fire visits to the area.



Image 23 Endangered dwarf kerrawang (*Commersonia prostrata*)

Image: Ken Turner/DPE

Large infestations of blackberry (*Rubus fruticosus* agg.) occur in the lower (northern) reaches of the Corang River at Oallen. This may inhibit Corang pine, as none were found in these areas.

The Corang pine does persist in areas where pine plantations (*Pinus radiata*) occur, bordering the river in both burnt and unburnt sites. However, competition with mature pines may affect the survival of recruits as observations of dead Corang pine have been made beneath these trees (Image 24).



Image 24 Patch of dead Corang pine juveniles beneath radiata pine (in white circle)
Image: M Appleby/DPE, 2020

5. Discussion

This survey confirmed an extension to the southern extent of the Corang pine. As the survey was not done upstream of the falls below Corang lagoon, it is possible that Corang pine occurs beyond this point, given the diversity of soil types and microhabitats within its documented range.

The 2023 survey increased our knowledge about Morton National Park habitat, however, this only protects a small proportion of Corang pine extent. Most of the Corang pine population occurs on private property, where there is uncertainty about continuing habitat protection and management. Vegetation clearing has become an increasing threat on private land, with 2 sites recently cleared, both in areas containing live adult Corang pine plants. Although a relatively minor disturbance, recently, unapproved bushwalking tracks have been created that traverse both private and national park land through Corang pine populations. These tracks increase the risk of trampling, weeds and plant disease.

The numbers of Corang pine seedlings have reduced significantly since the 2020–21 survey estimate of around 75,000 seedlings in total, or an average of 18 recruits per dead adult (Appleby and Wright 2021). It is difficult to quantify the reduction in seedling numbers, as the recent survey sampled plots within patches, rather than the continuous full site counts completed in 2020–21. Using the 2023 plot data, there were, on average, 5 surviving recruits for each dead adult counted. Apart from instances of vegetation clearing described above, ecological stressors such as competition (including intraspecific), browsing (particularly by *Callitris* sawfly larvae), and successive flood events have reduced seedling numbers. Nevertheless, much of the surviving recruitment is healthy and is beginning to reach reproductive maturity 3 years after the fire.

Although many more sites were surveyed in 2023 than in 2020–21 and the range of Corang pine marginally extended, only 89 live seed-bearing adults were found in the 24 km stretch of river surveyed, only 20 more than the 69 live adult plants found in the 2020–21 survey. Of particular concern were several plants that had survived the fire when last surveyed but had subsequently died. Some of these had been largely defoliated by *Callitris* sawfly larvae at the time of the last survey, which may have been the ultimate cause of their death. Other plants that were partially scorched but not burnt may have later succumbed to the effects of radiant heat. The effects of several flood events (uprooting/root exposure, plants swamped by debris piles) may have accounted for other deaths. Two individuals that could not be relocated at the Corang Post Office Road crossing were likely casualties of road grading. Plants on or adjacent to the Nerriga Road and access roads to properties west of this road remain vulnerable to routine road maintenance activities. Although wind-pollinated, flood-dispersed and less dependent on faunal vectors, the species remains at risk from low genetic diversity due to the small number of mature, seed-bearing plants (DCCEEW 2023). These mature individuals are spatially separated within 38 sites, and the numbers of trees each site contains ranges from 1 to 11. Many of these sites (48%) have only one tree, which has implications for cross-pollination between sites. The recovery of the Corang pine depends on the survival, to reproductive maturity, of recruits between the surviving mature trees.

While post-fire recruits are reaching reproductive maturity, these plants are still small (<800 mm, most <400 mm) and vulnerable. Many have signs of cockatoo predation of the few cones produced. Browsing by *Callitris* sawfly, which feeds exclusively on Corang pines, was observed throughout the survey, and had completely defoliated many juvenile plants. While Moore (1963) observed that most plants recovered after significant defoliation by larvae, the combination of stressors (drought, fire, flood, browsing, competition) on a largely juvenile population, and increasing frequency and severity of these events mean that the recovery of the population remains at risk.

Signs of feral herbivores (goats, deer, rabbits, pigs) were noted, but did not appear to be browsing adult plants or seedlings. However, Mackenzie and Keith (2009) noted that browsing by rusa deer (*Cervus timorensis*) had resulted in over 50% mortality of post-fire *Callitris endlicheri* seedlings, so potential browsing impacts need to be monitored and control undertaken as necessary. Feral animals can also cause considerable soil disturbance with resulting seedling death. This is particularly the case with pigs. Although native, wombats have had a noticeable impact post-fire on Corang pine recruitment, with large areas of soil disturbance impacting seedling establishment and survival.

Corang pine is absent where blackberry forms a closed canopy (NPWS 2001), as is the case in the vicinity of Oallen Bridge. It is generally absent where riverine shrubland is very dense (particularly areas of post-fire *acacia* and *cassinia* regrowth). Since the last survey there has been a marked decrease in sprawling colonising species, among them post-fire dominant weeds such as inkweed (*Phytolacca octandra*), which has all but disappeared from the area. Although weeds are not generally a significant threat at this time, they have the potential to limit habitat availability and need to be monitored. This is particularly the case with woody weeds such as blackberry. Broom (*Cytisus scoparius*) and willow (*Salix* spp.) are both potential threats, infesting many waterways in the district, particularly the nearby Shoalhaven River. Significant amounts of land clearing recently add to the risk of weed introduction, also the threat of pathogens. Corang pine does persist and reproduce in margins of radiata pine plantations and among pine regrowth, but recent decline and death of individual adult Corang pine and juveniles in these circumstances warrants further monitoring.



Image 25 **Corang pine seedlings**

Image: G Wright/DPE, 30 September 2022

In their review of all populations/subspecies of *Callitris oblonga* Nadolny and Benson (1993) regarded its distribution along waterways as being an artefact of fire. The species has

survived in, and is now confined to, less fire-prone riparian environments. Flooding is a regular source of disturbance in such riparian areas. The species has obviously evolved with this natural perturbation, with flood deaths triggering seedling recruitment. However, 2 major flood events within months of the 2019–20 fire uprooted live plants, moved large quantities of soil and probably emerging seedlings (Appleby and Wright 2021). Lack of vegetation due to fire increases floodwater velocity and bank erosion (DCCEEW 2023). There remain few live plants in flood-scoured areas at the river's edge. Climate projections for south-eastern Australia predict increasing numbers of extreme rainfall events and flood risk, lower rainfall overall and an increase in high fire danger days (AdaptNSW 2023). This increases the risk of both flood and fire, and their interactive effects, also potentially drought interactions.

Corang pines are killed by even moderate and patchy fire and do not resprout. This looks to be the case even with scorch, as evidenced by dead specimens with browned off scale leaves in unburnt patches close to burnt vegetation. While serotinous response of Corang pine to fire results in massive germination, survival of seedlings is patchy. In areas of particularly intense fire (with crown and topsoil affected) 5 of the 10 sites surveyed in 2020–21 had fewer than 10 seedlings post-fire. In the subsequent 2023 survey, 2 of these sites had no recruits present, with remaining sites having a very small amount of further recruitment.

No pre-fire baseline census was taken of Corang pine before the 2019–20 fire. Estimates of the population were in the vicinity of 10,000 plants (Nadolny and Benson 1993) and between 2,500 and 10,000 (NPWS 2001). The 2023 plots had a total of 4,750 plants, of which 4,691 were post-fire recruits. It is likely that the current population is somewhere in the range of 8,000–10,000, extrapolating from plot data. With only 89 mature plants counted in this survey, patchy recruitment, unexplained deaths of mature plants, browsing pressure, weed competition and predicted climate change impacts (increased drought, floods, severe weather events and fire danger days) the entire subspecies remains extremely vulnerable.

6. Recommendations

- Set up permanent monitoring plots (Nerriga Bridge; Kings Flat; Morton National Park near Smilers Creek, and Oallen/Welcome Reef; to be negotiated with relevant landowners) to monitor Corang pine population recovery and threats.
- Engage the Biodiversity Conservation Trust to work with landowners to manage recovery of Corang pine on private land, and protect this and other threatened species along the river corridor through conservation covenants or biodiversity stewardship agreements.
- Work with WaterNSW and South East Local Land Services to control feral animals posing a potential threat to the species.
- Work with Queanbeyan-Palerang Regional Council (QPRC) to protect the species in road corridors and to enforce appropriate control of weeds in priority sites.
- Work with QPRC, WaterNSW and the Environment Protection Authority (EPA) to investigate clearing in Corang pine habitat.
- In conjunction with these agencies, hold a field day to engage local landowners and provide practical advice on conservation management.
- Engage with bushwalking groups, affected landowners, NPWS and administrators of trail apps to prevent further access through areas with Corang pine (the existing flagged trail also cuts through patches of Nerriga grevillea *Grevillea renwickiana*).
- Investigate translocation of dense Corang pine regrowth on firebreaks and other regularly maintained tracks to suitable habitat nearby.
- Continue efforts to collect Corang pine seed responsibly with appropriate licensing, seed bank, propagate and replant locally.

7. References

AdaptNSW (2023) Climate change in the South East and Tablelands, AdaptNSW, accessed 01/06/2023.

Appleby M and Wright G (2021) 'Corang pine (*Callitris oblonga* subsp. *corangensis*) 2020 wildfire post-fire surveys', unpublished report prepared for NSW Department of Planning and Environment, October 2021.

Carter O and Walsh N (2010) *National Recovery Plan for the Dwarf Kerrawang Rulingia prostrata*, Department of Sustainability and Environment, Melbourne.

DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2023) *Conservation Advice for Callitris oblonga subsp. corangensis (Corang pine)*, Department of Climate Change, Energy, the Environment and Water.

DPE (Department of Planning and Environment) (2023) Dwarf Kerrawang – profile, NSW Threatened Species Profiles, NSW Department of Planning and Environment, accessed 01/06/2023.

DPIE (Department of Planning, Industry and Environment) (2020) *Callitris oblonga Fire Response Plan*, February 2020, NSW Department of Planning, Industry and Environment.

Gallagher R (2020) *Final list of plants requiring urgent management intervention*, Wildlife and Threatened Species Bushfire Recovery Expert Panel, Department of Agriculture, Water and the Environment, Canberra.

Harris S and Kirkpatrick J (1991) 'The distributions, dynamics and ecological differentiation of *Callitris* species in Tasmania', *Australian Journal of Botany*, 39(3):187–202.

Hill KD (1998) *Flora of Australia*, volume 48: 585–586, 'Ferns Gymnosperms and Allied Groups', ABRS/CSIRO Australia, Melbourne.

Mackenzie BDE and Keith DA (2009) 'Adaptive management in practice: Conservation of a threatened plant population', *Ecological Management and Restoration*, 10(s1):S129–S135.

Moore KM (1963) *The Cypress Pine Sawfly species Zenarge turneri Rohwer and Zenarge turneri rabus Moore*, Forestry Commission of NSW Research Paper 13.

Nadolny C and Benson J (1993) *The Biology and management of the Pigmy Cypress Pine (Callitris oblonga) in NSW*, Species Management Report No. 7, NSW National Parks and Wildlife Service, Hurstville.

NPWS (National Parks and Wildlife Service) (2001) 'DRAFT Management Plan for the Corang Pine (*Callitris oblonga* subsp. *corangensis*)', NSW National Parks and Wildlife Service, Hurstville.