Habitat Management Plan for the endangered Forty-Spotted Pardalote *Pardalotus quadragintus*

UNDERSTOREY NETWORK 2011

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Habitat Plan for the Endangered Forty-Spotted Pardalote *Pardalotus quadragintus*

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Cover photo: Penny Geard. Forty-Spotted Pardalote foraging in a White Gum ©.

Executive Summary

The Forty-Spotted Pardalote is an endangered bird found only in coastal areas of eastern Tasmania. It is a small bird with poor dispersal ability and has a narrow habitat range confined to dry sclerophyll forests containing more than 10% of White Gum (*Eucalyptus viminalis*). The species feeds solely on White Gum for manna, lerps and insects. Since European Settlement, half of this vegetation type has been lost to clearing whilst the remaining patches exist under severe pressure from agriculture, forestry and urbanisation. Currently there is estimated to be only 1500 breeding pairs in the wild, less than half of estimates a decade ago.

Deteriorating White Gum and habitat quality is considered to be the most significant factor underpinning the recent decline in the Forty-Spotted Pardalote population. A prolonged drought interacting with ongoing disturbances, such as grazing, will have exposed White Gums to severe stresses resulting in 'tree dieback', restricting regeneration and further isolating colonies that are already severely fragmented. Restoring and increasing the area of habitat available to the Forty-Spotted Pardalote is essential to ensure the survival of the species and safeguard against future environmental uncertainty.

Over the next two years, the Understorey Network will restore 50 ha of Forty-Spotted Pardalote habitat as part of a Commonwealth Government project funded through the Caring For Our Country program. This management plan provides a strategic framework for all organisations managing Forty-Spotted Pardalote habitat into the future. It contains a current assessment of the status of the Forty-Spotted Pardalote and its habitat. This management plan also provides a review and critique of restoration 'tools' commonly used and accessible to land managers, and also provides a conceptual model that illustrates what restoration techniques should be used given the various conditions of Forty-Spotted Pardalote habitat available. Specific colonies are identified for restoration works with priorities based on reward for the species from effort required for restoration.

For instance, securing better quality remnants with larger colonies are given greater priority than revegetating cleared land that connects isolated colonies given the latter would require high input for revegetation and lengthy delays before habitat is suitable. Colonies targeted for restoration have been prioritised as follows (in order of importance):

1. Deteriorating habitat with existing colonies that have:
    a. Greater than 10 breeding birds.
    b. Less than 10 breeding birds.

2. Deteriorating habitat where colonies are no longer found but have been in the past.

3. Deteriorating habitat where colonies have never been found but adjoin(s):
    a. Two or more existing colonies with greater than 10 breeding birds.
    b. An existing colony with greater than 10 breeding birds.
    c. Two or more existing colonies with less than 10 breeding birds.
    d. An existing colony with less than 10 breeding birds.

Landscape factors such as distance to nearest large colony (> 10 breeding birds) are to be considered when prioritising restoration works, with colonies in close proximity to larger feeder colonies given greater priority than colonies of similar size but further from large colonies.

The success of this habitat management plan will ultimately be determined by a stabilisation and possible increase in the Forty-Spotted Pardalote's population. At another level, success will be determined by how effective the prescribed restoration methods have been in increasing the quality of Forty-Spotted Pardalote habitat. This will be evaluated by ongoing monitoring of restoration sites as well as a long-term White Gum regeneration trial undertaken in partnership with NRM South. The long-term trial will examine the efficacy of regeneration and revegetation techniques in different habitat states to further refine restoration works in the future.

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Purpose

The Forty-Spotted Pardalote *Pardalotus quadragintus*, Gould 1838, is a nationally-endangered bird found only in coastal areas and islands of eastern Tasmania. It is assumed the species has never been widespread (Brown 1986) as it is has very specific habitat requirements: low altitude dry sclerophyll forests containing mature stands of White Gum *Eucalyptus viminalis* subsp. *viminalis* Labill (Brereton et al. 1997). However excessive clearing of *E. viminalis* forests since European Settlement for agricultural, forestry and urban development has severely limited the range of the species and the first major surveys estimated a population between 3000 (Brown 1986) and 4600 birds (Bryant 1997).

Over the past two decades there has been a considerable conservation effort to improve the Forty-Spotted Pardalatote population size. This has been realised through the 1991-1997 recovery plan (Bryant 1991) and 2006-2010 recovery plan (Threatened Species Section 2006). Key achievements of these recovery plans were increasing the area of habitat in formal and informal reservations from 55% to 77%, re-establishing *E. viminalis* cover through regeneration and revegetation projects and greater understanding of the relationship between the Forty-Spotted Pardalote and habitat characteristics. It was expected that these factors, along with a stabilising population and cessation of significant land clearing and major disturbances would improve the Forty-Spotted Pardalote population size (Threatened Species Section 2006). The most recent survey, however, has indicated the population has declined dramatically over the past decade to 1500 breeding birds and that this is most likely attributed to deteriorating habitat condition, especially on Bruny Island where the most significant population drop has occurred (Bryant 2010).

This habitat management plan provides a framework for all organisations that will be involved in managing, protecting and restoring habitat for the Forty-Spotted Pardalote. Based on knowledge of the relationship between the Forty-Spotted Pardalote and its habitat, the ecology of *E. viminalis*, major threatening processes and habitat management plans for similar species, a set of guidelines

are provided which decision makers should follow to achieve the greatest possible success.

The first part of this management plan discusses the current status of the Forty-Spotted Pardalote and its critical habitat. Information is sourced from a variety of government and technical reports, scientific publications and university theses. The most recent survey of Forty-Spotted Pardalote population and habitat was undertaken by Dr Sally Bryant on behalf of the Tasmanian Land Conservancy and the state government in 2009/2010 and readers are referred to her report (Bryant 2010) for a more detailed description of the current status of the Forty-Spotted Pardalote.

In the Management Strategies and Actions section, a range of techniques suitable for restoration of degraded Forty-Spotted Pardalote habitat are reviewed and discussed. These range from intensive actions that include large scale revegetation and top soil removal, to more passive actions such as altering grazing regime and covenanting unreserved high-quality private remnants. A state-and-transition model is developed which identifies the range of habitat conditions available and the level of intervention required to restore degraded remnants. This will assist land managers in deciding what restoration techniques should be used. Finally, a set of guidelines are established that will ensure restoration will be undertaken with maximum benefit to the Forty-Spotted Pardalote. Individual colonies are identified and prioritised for restoration with larger colonies given the highest priority.

Background about the Forty-Spotted Pardalote

LIFE HISTORY

The Forty-Spotted Pardalote is 9-10 cm in length and weighs approximately 10 g. It has a light olive green body with pale yellow colouring around the eye and rump, and black wings with obvious white spots (Figure 1; Threatened Species Section 2006). There are no distinguishable differences in appearance between sexes however males do have an identifiable breeding call (Woinarski and Bulman 1985). The species is distinguished from the two other Pardalote species found in Tasmania (Striated Pardalote *Pardalotus striatus* and Spotted Pardalote *Pardalotus punctatus*) by a shorter linear span (Woinarski and Bulman 1985), lack of head markings, duller colouring and shy behaviour (Threatened Species Unit 1998). Female Forty-Spotted Pardalotes are also active in territorial defence (Woinarski and Bulman 1985).

Breeding is from August to December and four to five eggs are laid per nest. Incubation is 16 to 20 days and fledgling period is 25 days with three to four fledglings raised per nest (Bulman et al. 1986). Nests are built with fine bark and are typically found in small hollows, spouts and gaps 2 to 5 cm in diameter of mature trees up to 38 m from the ground but can also be found in fallen dead logs, tree stumps and on the ground (Woinarski and Rounsevell 1983, Woinarski and Bulman 1985, Brown 1986). It is not known what age sexual maturity is reached. Life expectancy is expected to be at least three years and greater than six years if similar to other Pardalotes (Bryant 2010).

During the breeding season the Forty-Spotted Pardalote diet consists mostly of manna, a sugary resin produced by eucalypts as a response to insect attack (Woinarski and Bulman 1985), and lerp, a small hemispherical covering of psyllid nymps rich in carbohydrates (Ijima 2010). Psyllids, spiders, flies, caterpillars and wasps supplement the species diet and become the main food source in cooler months when manna is less abundant (Woinarski and Bulman 1985). *E. viminalis* is rich in manna and lerps and consequently the Forty-Spotted Pardalote has a high affinity for this tree species. Furthermore, the small, slender shape of *E.*

viminalis leaves is believed to allow greater accessibility for the Forty-Spotted Pardalote to forage compared to the broader-leafed co-occuring eucalypts (Dorr 1999; Ijima 2010). The Forty-Spotted Pardalote forages by pecking leaves whilst positioned on twigs as opposed to in the air or on bark/branches (Woinarksi and Rounsevell 1983). The species will spend the majority of its time foraging in *E. viminalis*, mostly in trees 11 to 25 m tall and at approximately 75% of the trees height (Woinarski and Rounsevell 1983, Woinarski and Bulman 1985, Brown 1986). The species is not adapted to long distance dispersal and has a small foraging range of 1-2 trees, which is determined by tree quality rather than area (Woinarski and Bulman 1984). However in winter, dispersal away from large core patches to smaller less established patches occurs when food availability is critically low (Woinarski and Bulman 1984, Bulman et al. 1986, Dorr 1999, Threatened Species Unit 2006).

Figure 1. Forty-Spotted Pardalote (Tzaros, C. 2011)

DISTRIBUTION

Following extensive resurveying of known Forty-Spotted Pardalote colonies by Bryant (2010), the current population is estimated at 1500. This represents a significant decline in population over a decade given previous surveys indicated a stable population between 3000 and 4600 (Figures 2, 3; Brown 1986, Bryant 1997, Threatened Species Section 2006).

Habitat modelling has shown that the Forty-Spotted Pardalote is found less than 5 km from coastlines on fertile shallow soils near creek lines at below 100 m altitude with relatively high mean temperatures and low rainfall (Brereton et al. 1997). The species is a habitat specialist restricted to dry sclerophyll forests that contain a minimum of 10% projective foliage cover of *E. viminalis* (Brereton et al. 1997). The Forty-Spotted Pardalote can be found in six of the fifty forest ecosystems recognised by the Comprehensive Regional Assessment as part of the Tasmania Regional Forest Agreement 'RFA' (Threatened Species Section 2006). These include White Gum coastal shrubby forest on holocene sand, Dry Stringybark *E. obliqua* forest, White Peppermint *E. pulchella*/Blue Gum *E. globulus*/ White Gum grassy shrubby dry sclerophyll forest, Black Gum *E. ovata*/White Gum forest and Black Peppermint *E. amygdalina* forest on a sandstone substrate.

The recent survey by Bryant (2010) identified five sites where the Forty-Spotted Pardalote occupies. These are Maria Island, Bruny Island, Howden, Tinderbox and Coningham. A known population at Flinders Island was not resurveyed (this will be resurveyed as part of the project during 2011). It is estimated that there are 119 colonies occupying these five sites across a cumulative area of 3812 ha. Survey results showed the largest populations at Maria Island at 974 (23 colonies, 2030 ha) and Bruny Island at 450 (76 colonies, 1622 ha). Tinderbox is also estimated to have a significant population of 46 birds (12 colonies, 111 ha), whereas ten or less birds (1-2 colonies) are estimated at Howden (20 ha) and Coningham (8 ha).

Bruny Island and Tinderbox showed the greatest relative decline since the previous survey with a drop in population by ca 77% and 66% respectively (Bryant 1997, Bryant 2010). No birds were detected in a small 2 ha site at Taroona and it has been two decades since Forty-Spotted Pardalotes have been detected at a 27 ha site at Lime Bay (Brown 1986, Bryant 2010).

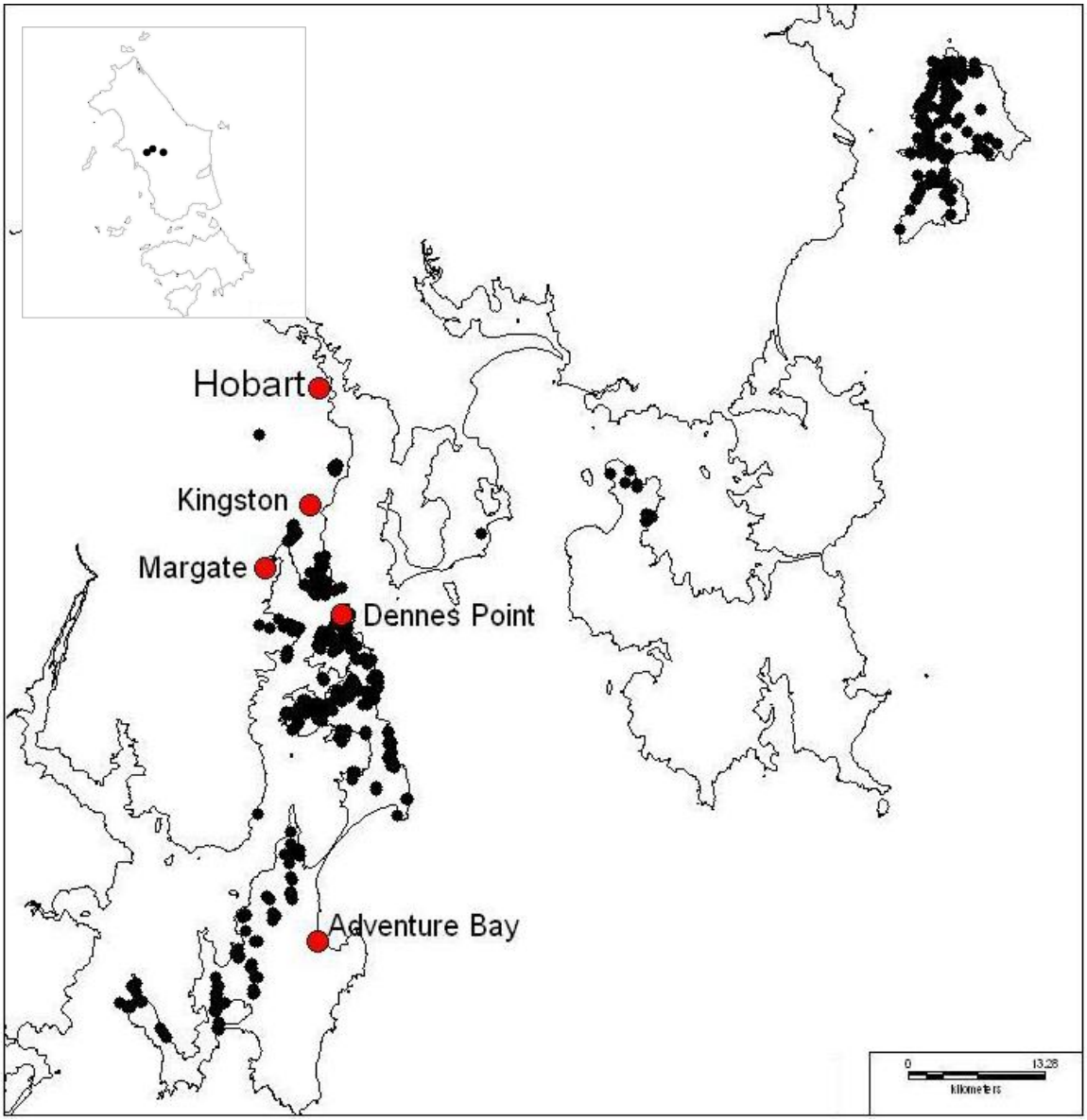

Figure 2. Historic distribution (●) of Forty-Spotted Pardalote in south-eastern Tasmania and Flinders Island (see insert). GDA 94.

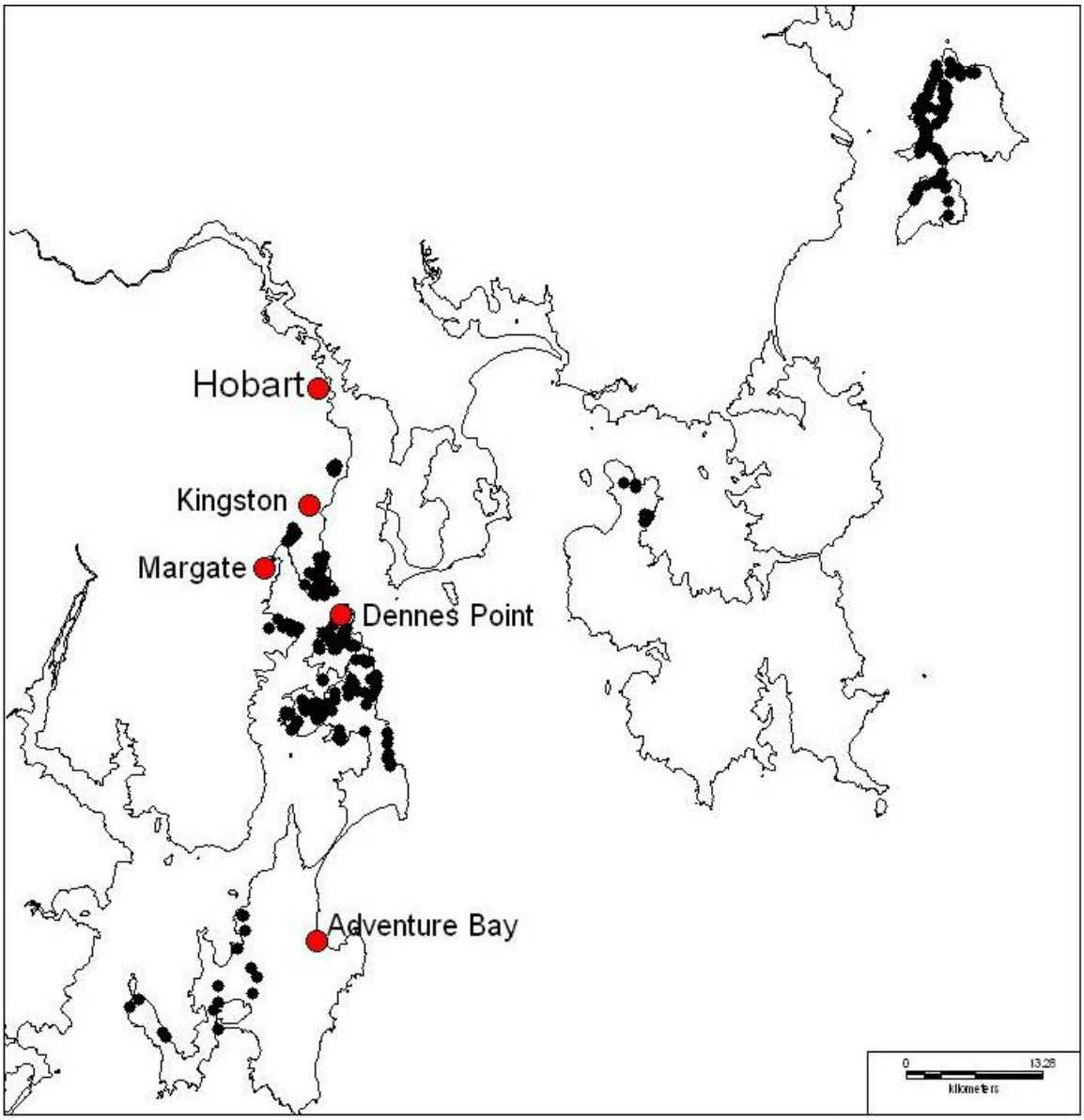

Figure 3. Current distribution (●) of Forty-Spotted Pardalote according to 2009/2010 survey by Bryant et al. (2010). Flinders Island colonies were not surveyed. GDA 94.

ESSENTIAL HABITAT REQUIREMENTS

It is well established that the presence of *E. viminalis* is an essential habitat requirement for the Forty-Spotted Pardalote (Woinarski and Rounsevell 1983, Woinarski and Bulman 1985, Brereton et al. 1997, Bryant 2010). Compared to other pardalotes, the Forty-Spotted Pardalote is highly restricted to stands of dry sclerophyll forest containing *E. viminalis* (Woinarski and Rounsevell 1983). The species is most common in stands dominated by *E. viminalis*, however can be observed in mixed eucalypt forests with a minimum of 10% *E. viminalis* projective foliage cover, and *E. obliqua, E. amygdalina, E. globulus, E. tenuiramis, E. ovata* and *E. pulchella* as dominants/co-dominants (Woinarski and Rounsevell 1983).

Breeding occurs mostly in standing over mature trees, although this varies between sites. On Maria Island nesting was observed to be largely in tree hollows on live *E. viminalis* branches (Brown 1986) compared to Bruny Island where less than half of nests were observed to be in tree hollows with breeding also occurring in fallen branches, tree stumps and on the ground (Woinarski and Bulman 1985). Nevertheless, these findings further emphasise preference for mature vegetation which provides both feeding and nesting opportunities. Thus immature revegetation sites and regrowth forests regardless of the amount of *E. viminalis* are unlikely to be suitable habitat for the Forty-Spotted Pardalote (Woinarski and Rounsevell 1983, Bryant 2010).

Very little is known about the dispersal distance of the Forty-Spotted Pardalote. Dispersal between North Bruny Island and the Tasmanian mainland sites, e.g. Tinderbox and Howden, has been noted (Brown 1986), however the species is generally regarded as having a small dispersal range (Threatened Species Unit 1998). It is therefore difficult to determine the maximum distance between suitable patches which can still support dispersal. It is also difficult to determine the minimum patch size. For instance, it is estimated that a 0.5 ha patch with only 5% *E. viminalis* is sufficient for a single breeding pair (Threatened Species Unit 2006), however ca 70% of colony sites on Bruny Island that had no birds

detected during the most recent survey are less than 10 ha in size and 40% less than 5 ha (Bryant 2010).

Relationships between habitat variables (e.g. canopy cover, stem density, recruitment) and number of birds detected have been tested in several studies (Woinarski and Rounsevell 1983, Woinarski and Bulman 1985, Bryant 2010). Bryant (2010) found that habitat plots where birds were detected had more *E. viminalis* stems per hectare as a percentage of total eucalypt stems, compared to habitat plots where birds were not detected. There was no such relationship with total eucalypt stems per hectare. Woinarski and Bulman (1985) also found a significant negative correlation between tree density and number of sightings, highlighting a preference for more open stands. It has also been shown that the Forty-Spotted Pardalote is highly sensitive to disturbance and can only tolerate some minor disturbance, e.g. low impact grazing (Woinarski and Rousenvell 1983, Bryant 2010).

Figure 4. Juvenille Forty-Spotted Pardalote nesting in a White Gum.

HABITAT CONDITIONS ACROSS RANGE

A recent survey of habitat plots across the entire Forty-Spotted Pardalote range showed a general decline in condition. Using both qualitative and quantitative methods, Bryant (2010) found 68% of habitat plots had inadequate levels of recruitments, 49% had declining projective foliage cover and 40% had insufficient over-mature trees to provide breeding habitat.

On Bruny Island where the greatest decline in population has occurred, 43% of habitat plots have deteriorating habitat (Bryant 2010). Of these deteriorating habitat plots, 45% are considered to be undergoing wide spread decline (i.e. thinly scattered trees with small canopies and many dead trees). A further 34% are considered to be in serious decline and contain *E. viminalis* trees in poor conditions and 21% contain no living *E. viminalis* and are not expected to support the Forty-Spotted Pardalote until regeneration occurs. Birds were only detected in 38% of habitat plots considered to have deteriorating habitat (Bryant 2010).

Across the six RFA communities the Forty-Spotted Pardalote is observed, three communities are listed as rare, vulnerable and/or endangered under Schedule 3a of the Nature Conservation Act 2002. These are *E. amygdalina* forest on a sandstone substrate (vulnerable), *E. viminalis* coastal shrubby forest on Holocene sand (rare and vulnerable) and *E. ovata*/*E. globulus* forest (endangered).

RESERVATION STATUS OF HABITAT ACROSS RANGE

The area of Forty-Spotted Pardalote habitat in reserves has increased from 55% of total habitat to 77% since the first recovery plan for the species (Bryant 1991, Bryant 2010). There are now 3158 ha of habitat reserved, the large majority of which is found in formal state reserves. Habitat has also been reserved through incorporating prescriptions for habitat conservation into urban and forestry management plans, however the success of these prescriptions is contentious. In

some instances, retention of large hollow bearing trees, key habitat for the species, has not been achieved (Bryant 2010).

All habitat for populations on Maria Island and Flinders Island is included in state reserves. In contrast less than half of the habitat on Bruny Island is reserved either formally or informally, with approximately 868 ha of unreserved habitat found on private property. Similarly, only 35% of habitat on the Tinderbox Peninsula is reserved (Bryant 2010). There is estimated to be only 2 ha of unreserved habitat at both Howden and Coningham, however this is relatively a significant amount given the small amount of habitat at both locations (20 ha and 8 ha respectively; Bryant 2010, Ijima 2010).

THREATS

Undoubtedly clearing of habitat has been the number one threat to the Forty-Spotted Pardalote (Threatened Species Section 2006). Agriculture, forestry and urban pressures have seen the reduction in *E. viminalis* grassy forest cover by more than half since European Settlement. There has also been significant clearing of dry sclerophyll forest along coastal areas (Threatened Species Section 2006). As the species is a habitat specialist, any reduction in key habitat is going to have direct implications on the population size.

Over the past 10 years land clearing has been negligible across the Forty-Spotted Pardalote range (Bryant 2010). However, the indirect consequences of changes to habitat configuration or ‘fragmentation’ persist and remain as threatening processes. Perhaps most importantly is the increase in habitat edges which encourage larger, more aggressive edge-specialists at the detriment of smaller, less competitive birds such as the Forty-Spotted Pardalote. Interspecific competition requires the Forty-Spotted Pardalote to spend more energy defending their territory and less time foraging (Woinarski and Bulman 1985) and they are likely to abandon their territory when it is too energy inefficient to remain.

The Noisy Miner *Manorina melanocephala* is the classic aggressive edge-specialist across temperate Australia. Its expansion into the Forty-Spotted

Pardalote range has been associated with the extinction of local Forty-Spotted Pardalote colonies (Threatened Species Section 2006). The Black-headed Honeyeater, Striated Pardalote, Starling and Laughing Kookaburra are also potential threats to the Forty-Spotted Pardalote (Woinarski and Bulman, Threatened Species Section 2006). In urban areas, there is expected to be a competitive advantage of medium sized birds over the Forty-Spotted Pardalote as they can take advantage of food and water resources available in gardens (Ilijima 2010). Feral cats have also been identified as a threat to the species given that nests can be found on or near the ground (DEWHA 2008).

Other fragmentation-related effects threatening the species survival is isolation of habitat. On Bruny Island 76 colonies have been identified most of which are small and separated by small distances (Bryant 2010). Some are separated despite continuous native forest cover between colonies. Little is known about the dispersal range of the species, or how penetrable certain vegetation types or land uses are, i.e. the 'matrix'. For instance can the species disperse through plantation forests or across pastures? What native forest characteristics are important to support dispersal? Urban impacts also need to be considered. Population size decreased by half at Howden over the previous decade despite habitat remaining in suitable quality to support the Forty-Spotted Pardalote (Bryant 2010, Ilijima 2010). During this period building numbers doubled and it was suggested that urban disturbance was the leading contribution to population decline at this location (Ilijima 2010).

Within-fragment effects are a threatening process as the Forty-Spotted Pardalote is sensitive to disturbance. Disturbances that reduce canopy cover of *E. viminalis* i.e. 'dieback', reduce the availability of food and nesting resources and increase interspecific competition. On Bruny Island most of the unreserved habitat is subjected to grazing. Grazing history is one of the major causes for eucalypt decline in Tasmania and has a significant effect on the overall soil health of sites (Davidson et al. 2007, Close et al. 2008). Fire can potentially destroy populations if intensity is great enough to scorch the crown (Woinarski and Bulman 1985). A severe wildfire in 2003 destroyed significant habitat on Flinders

Island and these colonies are yet to have re-established (Threatened Species Section 2005). Removal of standing and falling wood and debris also needs to be controlled as it limits potential nesting sites (Threatened Species Section 2005).

Drought has a significant impact on food availability for the Forty-Spotted Pardalote and may have been the major contributing factor to the dramatic decline in species numbers over the past decade (Bryant 2010). Over this period there had been little change in land use and management and no significant disturbance events. There was however, a continuous drought that extended through much of southern Australia. Production of manna and insect richness is greatly reduced during drought and eucalypts regularly show signs of dieback. The effect of grazing on soil compaction and therefore water infiltration can further exacerbate the effects of drought (Yates 2000).

Management strategies and actions

This section is a review of the 'management tools' available to restore and protect Forty-Spotted Pardalote habitat. These range from intensive soil remediation and revegetating severely degraded habitat to covenanting high quality *E. viminalis* remnants. Prescriptions for a range of restoration techniques are summarised in Table 1. As with similar projects the success of habitat restoration will be largely dependent on landholder participation. However, given the limited funding available, it is important to have a strategic plan that ensures the maximum return on costs for the Forty-Spotted Pardalote. A set of objective guidelines are provided and target areas are identified to assist decision makers in prioritizing on-ground works that have the greatest likelihood of improving the Forty-Spotted Pardalote population. Such an approach has been highly successful in restoring habitat for the endangered Regent Honeyeater in north-eastern Victoria (Thomas 2009).

Across the Forty-Spotted Pardalote range, habitat varies from intact with little to no disturbance history, high quality urban remnants with severe pressure from human disturbance, to highly degraded remnants with few standing *E. viminalis* trees and understorey dominated by exotic grasses and a long history of agricultural disturbance. To assist land managers in considering what level of intervention is required to restore habitat, a process model is provided that identifies the various states of Forty-Spotted Pardalote habitat and the required intervention for a transition to occur to a higher level that overcomes abiotic and biotic thresholds, i.e. a 'state-and-transition model'. The highest state in most state-and-transition models for Australian landscapes is pre-European settlement condition. However, this state-and-transition model is simplified to aim for the ideal habitat attributes for the Forty-Spotted Pardalote: mature stands of dry sclerophyll forests within 3 km of coastlines and >10% *E. viminalis* cover, 2 dead trees per 20 stems to support one breeding pair and no Noisy-Miner presence.

REVEGETATION

Revegetation for conservation purposes has been undertaken in Tasmania for several decades. Over this time methods and techniques have improved resulting in increased species diversity and lower mortality rates. Increased efficiencies have allowed greater areas of revegetation to occur and greater uptake by large landholders. There is now a level of expertise within government and non-government organizations as well as environmental groups that can provide vital knowledge on how to revegetate for success.

Nonetheless, the cost and ongoing labour demands (i.e. weeding and watering) of revegetation remains high. Large scale revegetation should only be considered in severely degraded remnants with no onsite propagules, when other cheaper restoration tools have little chance of success. There is good potential, however, for small-scale targeted revegetation in urban areas, such as the Tinderbox and Howden region, with conservation-minded landholders. For instance 10-20 *E. viminalis* seedlings could be easily managed by a single landowner, and provide necessary links between isolated patches or increase feeding resources as well as increase awareness of the species plight within urban communities.

Where it is appropriate for large-scaling revegetation, the attributes that are attempting to be restored must be kept in mind (Maron 2007). For instance, high density plantings delay diameter growth and eventual provision of potential nesting sites, such as hollows and fallen branches (Vesk et al. 2008). Low density plantings that promote tree growth and greater canopies are recommended to provide long-term habitat for the Forty-Spotted Pardalote and provide niches for the recruitment of understorey species (Vesk et al. 2008). Planting along fertile, wetter soils will also improve the productivity of revegetation (Thomas 2009). To compensate for the timelag in nesting resources, retention of dead trees and fallen logs is necessary.

Experiments undertaken in Tasmania have shown that factors which increase survival of *Eucalyptus* tubestock plantings include: soil preparation, using more mature tube stock, tree guarding, watering immediately after planting and after

the first year of planting, and follow up weeding (Close and Davidson 2002, Close et al. 2010). Soil mounding is better than ripping to reduce soil compaction impacts associated with grazing as it avoids cracking of deep clay soils and enhances soil moisture retention (Close and Davidson 2002). Spot burning, mulching with native litter and companion understorey plantings has little benefit (Close et al. 2010). The benefit of using more mature tube stock is likely to do with larger lignotubers and greater nutrient reserves (Close and Davidson 2002). Experiments investigating sown seed of *E. viminalis* have found that it germinates more successfully buried at a depth of 1 cm then on the surface (Clarke and Davison 2001).

Revegetation projects that are intended to increase bird diversity or bird abundance can have the opposite effect. The aggressive and territorial Noisy Miner has increased its dominance by taking advantage of revegetation sites at the expense of all other bird species (Majors et al. 2001, Maron 2007). The Noisy Miner does exist within the Forty-Spotted Pardalote range, being particularly prevalent in the Tinderbox and Howden region (Threatened Species Section 2006) and has been observed on Bruny Island (Bryant S. pers comm.).Therefore any revegetation for Forty-Spotted Pardalote habitat should carefully consider potential interactions with the Noisy Miner and other aggressive edge-specialist species (Maron 2011). Revegetation should focus on improving the spatial configurations of existing remnants to discourage the Noisy Miner. Noisy Miners prefer smaller remnants. They can penetrate 300 m from remnant edges meaning remnants smaller than 36 ha can be exclusively dominated by Noisy Miners (Macdonald and Kirkpatrick 2003, Piper and Catterall 2003, Clark and Oldland 2007). Thus revegetating to increase the size of small remnants should be a priority.

Projections or peninsulas from remnant edges as well as isolated clumps of trees assist Noisy Miner invasion (Taylor et al. 2008). Incorporating these geometric attributes through revegetating out from remnant edges could also reduce the bird’s dominance. Similarly, it is highly likely that narrow linear revegetation corridors will become dominated by the Noisy Miner and facilitates their spread

(Majors et al. 2001, Clark and Oldland 2007). Species poor plantings consisting largely of eucalypt species can also promote the spread of Noisy Miners (Hastings et al. 2006). Eucalypt plantings without understorey have been found to be dominated exclusively by Noisy Miners, whereas plantings that contain >15% cover of bipinnate acacias have a greatly reduced presence of Noisy Miners (Hastings et al. 2006). Because of this, all plantings of *E. viminalis* should be combined with *Acacia dealbata*, an indigenous bipinante acacia.Grevillias and callistemons which increase the food supply for the Noisy Miner should be avoided (Hastings et al. 2006). However, Forty-Spotted Pardalotes are known to engage with Noisy Miners whenever in their territory (Bryant S pers comm.) and so providing sheltering sites for the Forty-Spotted Pardalote may not provide any benefit. Therefore, there should be a stronger emphasis on designing revegetation to reduce Noisy Miner abundance rather than increasing sheltering sites for the Forty-Spotted Pardalote.

SOIL REMEDIATION

Poor soil condition can be the biggest impediment to restoring degraded land. Sites that have been subjected to a heavy grazing regime are associated with greater soil compaction reducing infiltration, greater soil nitrogen and phosphorous pools and a soil seed bank dominated by exotic annual species (Davidson et al. 2007, Close et al. 2008, Fischer et al. 2009). These conditions are also associated with remnant tree dieback and generally poorer remnant health, as well as a decline in woodland bird communities across Australia (Watson et al. 2011). Re-establishing the Forty-Spotted Pardalote and restoring important ecosystem services may require addressing these soil conditions that go beyond simply removing grazing and fertilization.

Greater nutrient availability provides a competitive advantage to exotic annuals causing a reduction in native species richness and abundance. Increased soil nitrogen availability also leads to tree dieback through increased defoliation by insects. Prober et al. (2005) successfully reduced available nitrogen in temperate woodlands by increasing soil carbon through the application of commercial sugar

(sucrose). Increasing the C:N ratio of soils increases activity of decomposing soil microorganisms that compete with plants for nitrogen. There was a positive feedback from this technique, whereby increased recruitment of native perennial vegetation further reduced nitrogen availability through locking away nitrogen in storage organs. Prober et al. (2005) did note that the establishment of perennial grasses is vital to reduce soil nitrogen as the effect of carbon application is transitory. In a similar approach, the harvest waste of commercial eucalypt plantations could be applied because of the high C:N ratio of leaves (Archibald et al. 2011). Seedlings would also benefit from the improved microclimate and protection from grazing provided by the harvest waste (Archibald et al. 2011). In contrast repeated burning and mowing has no impact on soil nitrogen or carbon and high frequency burning can form a seal on the soil surface further reducing soil infiltration (Prober et al. 2008). Whilst a range of these techniques have potential, few have been applied on an industrial scale. Establishing native perennial grasses is recommended as the best method for reducing exotic annual species by depleting access to soil nitrogen.

Soil compaction from grazing exacerbates the effect of drought on trees (Watson et al. 2011) and may have been the leading cause of habitat decline on Bruny Island over the past decade. Soil compaction can be improved by cultivating the soil, usually achieved through mounding or ripping with mounding having the best results in eucalypt plantings in Tasmania. Increasing moisture retention on undulating sites could also be achieved by creating swales or terraces that capture runoff.

Removing exotic propagules from sites will encourage natural regeneration and improve the success of plantings. This can be achieved through depleting the soil-seed bank reserve of exotic annuals by repeated spring burning during their flowering period (Prober et al. 2009). Repeated spraying with herbicide is likely to have similar results. On severely degraded sites where native species are absent or present in insignificant amounts a more intensive intervention of soil scalping will yield the best results and is easier to apply on an industrial scale especially in agricultural landscapes. Gibson-Roy et al. (2010) found that removing top soil to

a depth of 10 cm along with a preapplication of herbicide removed all exotic species. A similar result should be achieved by removing only the top 1-2 cm as exotic seeds are not found below this depth.

GRAZING

Eucalypt decline is strongly associated with agricultural disturbance (Dorrough and Moxham 2005, Fischer et al. 2009, Weinberg et al. 2011). In Tasmania's woodlands, tree health has been found to be negatively affected by profound changes in soil attributes as a result of grazing (Davidson et al. 2007, Close et al. 2008). Simply fencing and removing stock can be a positive first step to encourage natural eucalypt regeneration, providing there is a source of propagules, and soil conditions and other abiotic factors are conducive to germination. The likelihood of regeneration can be predicted by native perennial grass cover (Spooner and Briggs 2006) and native understorey cover (Weinberger et al. 2011) which are both sensitive to grazing pressures and therefore indicative of grazing regime, along with land tenure (Dorrough and Moxham 2005, Weinberger et al. 2011). Eucalypt regeneration is poor or unsuccessful on sites subjected to a prolonged heavy grazing history, in small remnants and on private land (Dorrough and Moxham 2005, Weinberg et al. 2011).

Removal of stock is not always a viable option due to the high opportunity cost to landholders. Landholders are likely to be more receptive to an altered grazing regime rather than complete cessation of stock. Regeneration potential can be as great under light to moderate grazing pressures as no grazing at all (Weinberger al. 2011). Rotational- or cell grazing, where paddocks are grazed for short, intense periods followed by a long fallow period is a sustainable grazing regime growing in popularity with landholders largely due to the reduced pasture growth during the recent drought. Fast-rotational grazing has been found to be just as successful as no grazing at all for eucalypt regeneration (Fischer et al. 2009), with improvements in soil infiltration and reductions in weed abundance likely

explanations. A current trial on Bruny Island by NRM South will provide valuable information on how altering grazing regimes influence *E. viminalis* regeneration.

There is anecdotal evidence that wildlife browsing also limits the success of revegetation and regeneration. Fencing should be sufficient to reduce the incursion of wildlife and tubestock should be adequately guarded. Where wildlife proof fencing is not possible, due to its high cost, game control measures should be considered.

CONTROLLED BURNING

Along with reduced exotic species abundance, controlled burning may encourage regeneration through stimulating seed release from capsules and providing a cleared ashbed for germination. *E. viminalis* stores its soil in the canopy with peak mature seed fall occurring in February/March and extending to September/October (Dooley et al. 2010). Similar to other *E. viminalis* subspecies the Tasmania subspecies is not expected to have a soil seed bank (Wills and Read 2002). It has also been shown that burning has no impact on *E. viminalis* soil sown seed (Clark and Davison 2001). Therefore burning should only be carried out in the peak seed fall months to encourage regeneration. Increasing the volume of coarse woody debris on a site may further enhance regeneration following fire. The moister and more protected conditions near large logs provides suitable microclimate for eucalypt regeneration in Tasmania's dry sclerophyll forests following fire (Davidson, N. pers comm.).

COVENANTING

For unreserved, high-quality remnants of Forty-Spotted Pardalote, attaching a conservation covenant to the title of these properties will ensure their environmental values are protected into perpetuity. Covenants also contribute to Australia's Natural Reserve System. The Private Land Conservation Program established by the Department of Primary Industries, Parks, Water and Environment (DPIPWE) helps to establish covenants, as well as non-binding

programs such as Land for Wildlife that support and encourage landholders actively involved in conservation. The Tasmanian Land Conservancy also offers assistance in covenanting through their Protected Areas on Private Land program.

PRESCRITIONS

Table 1. Prescriptions for restoration of Forty-Spotted Pardalote habitat

What	Where	When	How
Tubestock planting	- Degraded remnants with no onsite propagules. - Bushblocks and gardens. - Corridors between isolated colonies.	May to June	Soil preparation – Spraying with a nonresidual herbicide. Soil mounding to increase soil moisture retention. Planting – Mature stock grown from provenance seed. High density plantings (1 seedling m^{-2}) and inclusion of *Acacia dealbata* and other bipinnate acacias to discourage Noisy Miner. Ratio of 7:3 White Gums to understorey species. Mulch mats to prevent weed growth. Bag and stake with wire mesh guards to prevent browsing of seedlings. Water in well and add water crystals. Follow up – Remove weeds and water 12 months after.
Direct seeding	- Degraded remnants with no onsite propagules. - Degraded remnants with significant exotic grass cover and elevated soil nitrogen.	May to June	White Gum – Bury seeds 1 cm below surface Native grasses – Spread onto cleared disturbed surface.
Fencing	- High quality remnants with no regeneration.	All year round	Fence around perimeter of high quality patches to encourage natural regeneration. In areas where marsupial browsing is an issue include a marsupial proof fence where practical or undertake culling program.
Burning	- Remnants with onsite propagules.	High seed fall periods – late summer through autumn	Low intensity burn around base of remnant White Gums to provide a cleared soil surface for regeneration. Avoid high intensity burns which will scorch crowns.

Table 1 continued.

What	Where	When	How
Grazing	- Remnants that are grazed where sufficient natural regeneration is occurring. -Mature revegetation sites with significant exotic grass cover.	Spring –flowering period of most exotic grasses.	Where regeneration is already occurring, maintain grazing regime. In revegetation sites crash graze until weed biomass is depleted. Remove stock immediately if revegetation is being grazed.
Scalping	- Degraded remnants with high exotic grass cover, insignificant native understorey and high soil nutrient levels.	All year round but preferably during high seed fall periods.	Remove top 2 to 5 cm of soil with either a mattock or in larger areas with a grader. Works best when combined with spraying.
Spraying	- Remnants and revegetation sites with high exotic species cover.	Spring –flowering period of most exotic grasses.	Most annual exotic grasses will respond negatively to glyphosate. Refer to Weeds, Pests and Diseases section of DPIPWE website for controlling techniques for specific weeds. Weed removal will work best when combined with other technique, i.e. scalping.

State-and-Transition Model for Forty-Spotted Pardalote Habitat

Habitat conditions vary considerably across the Forty-Spotted Pardalote's range and restoration techniques will vary according to habitat condition. To assist land managers in what restoration techniques are required for a site, a state-and-transition model is provided showing the necessary actions to overcome restoration barriers and improve the quality of habitat (Fig. 5). The model identifies five states of habitat condition that are representative of current Forty-Spotted Pardalote habitat and will be targeted for restoration. For instance sites with no extant or dead *E. viminalis* trees are not included in the model due to the considerable cost required to restore these remnants, whereas sites that have at least one attribute of the Forty-Spotted Pardalote's habitat, e.g. dead *E. viminalis* trees, is included in the model. The model also considers the most common forms of disturbance: grazing, clearing, fire wood collecting and burning.

Table 2. Summary of transitions and thresholds in state-and-transition model

Transitions	
T1	Transition from moderate quality habitat 1 to high quality habitat
T2	Transition from moderate quality habitat 2 to high quality habitat
T3	Transition from poor quality habitat to moderate quality habitat 1
T4	Transition from severely degraded habitat to poor quality habitat
T5	Transition from severely degraded habitat to moderate quality habitat 1
Regeneration thresholds	
B1	High weed presence in vegetation and soil seed bank along with elevated soil nutrients caused by intense grazing history.
B2	No available propagule source.

The highest quality habitat will satisfy all of the structural and compositional attributes of Forty-Spotted Pardalote habitat; mature overstorey with greater than 15% canopy cover, greater than 10% *E. viminalis* canopy cover, sufficient number of dead trees and fallen logs to satisfy breeding requirements and

ongoing recruitment of overstorey species to replace dead trees. Because of the invasiveness of the Noisy Miner, remnants should be at least 36 ha to ensure a core habitat that's Noisy Miner free. Although presence of native understorey species and a grassy layer dominated by native perennials is not a requirement for the Forty-Spotted Pardalote, these attributes will be highly associated with intact remnants and indicative of a site with no or little grazing history. The majority of this habitat condition will already be reserved. Habitat on private land should be prioritized for covenanting or at a minimum exclude exogenous disturbances.

Habitat that has had a history of light to moderate grazing will still have the important ecosystem processes that support Forty-Spotted Pardalote habitat and a worst-case scenario would be that these processes are impaired rather than extinct. Remnants that have a similar overstorey structure and nesting habitat to high quality remnants, but no *E. viminalis* recruitment and have some exotic species but has a grassy cover dominated by native perennial grasses (moderate quality habitat 1) could be restored to high quality habitat through removing grazing altogether, particularly where there is evidence of tree dieback, or 2) where mature *E. viminalis* trees are healthy implementing a grazing regime that supports recruitment (T1). In this state, remnants have sufficient seed production and abiotic conditions are conducive for germination however grazing pressure limits the survival of seedlings preventing the recruitment of new individuals. Ecological thresholds have not been exceeded by grazing disturbance therefore altering the grazing regime shall be sufficient to restore the site to high quality habitat. If the site is smaller than 36 ha and Noisy Miners are present, restoration should include increasing the patch size to greater than 36 ha whilst maintaining a low perimeter-to-area ratio, i.e. limiting edge effects

Habitat of a moderate quality that has ongoing recruitment of *E. viminalis* and has been exposed to log removal or bushfire will have sufficient cover of *E. viminalis* in the overstorey or a maturing stand of *E. viminalis*, but will be devoid of nesting habitat: fallen logs and very mature or dead trees (2 per 20 stems; Bryant S. pers comm) with hollows (moderate quality habitat 2). With a significant

time lag until nesting resources are provided, these remnants require incorporating adjoining patches which include isolated or clumps of dead trees (T2). The addition of large logs should be undertaken where it does not negatively impact on the nesting habitat from where it is sourced. As with T1, restoration may also require increasing the patch size and improving the patch geometry to reduce the abundance of Noisy Miners.

Poor quality habitat will have had a moderate to heavy grazing history with little native understorey and native perennial grasses with a ground cover dominated by exotic species. There will be a large number of dead trees and less than 15% overstorey cover. *E. viminalis* density will be less than four trees per hectare and cover will be less than 10%. There will also be no recruitment of *E. viminalis*. In these remnants an ecological threshold has been crossed due to excessive grazing (B1) requiring intensive intervention that goes beyond altering grazing regime to restore habitat quality (T3). Due to soil compaction, high soil nutrient load and dominance of exotic species in the soil seed bank and standing vegetation, the abiotic conditions contribute to tree dieback and prohibit recruitment. Along with altering the grazing regime, remnants will require reducing available nitrogen in the soil through the application of a carbon substance (i.e. sucrose or residue from eucalypt forest harvesting) and/or establishing native perennial grasses. Burning or spraying with a non persisent herbicide near *E. viminalis* canopies during seed fall will help create microsites for seedling establishment. However, due to a small tree density, seed production will be low and small scale plantings of *E. viminalis* will be required to complement natural regeneration. A minimum of four trees per hectare is required for adequate seed dispersal based on calculations for other eucalypts of similar height and seed weight (Kasel 2004).

A long history of heavy grazing will result in severely degraded habitat that in the absence of broad scale clearing will have standing trees but no live overstorey or native understorey and a groundcover completely dominated by exotic species. Large scale revegetation (T4) will be necessary to provide *E. viminalis* recruitment due to the absence of an onsite seed source (B2). Recruitment from

seed will still be prevented once the planted trees are sexually mature if soil conditions are not addressed in a similar fashion to poor quality remnants (T5). Given the complete dominance of understorey species, removing the top 2 cm of the soil profile with scalping can improve revegetation success and regeneration success once trees are mature.

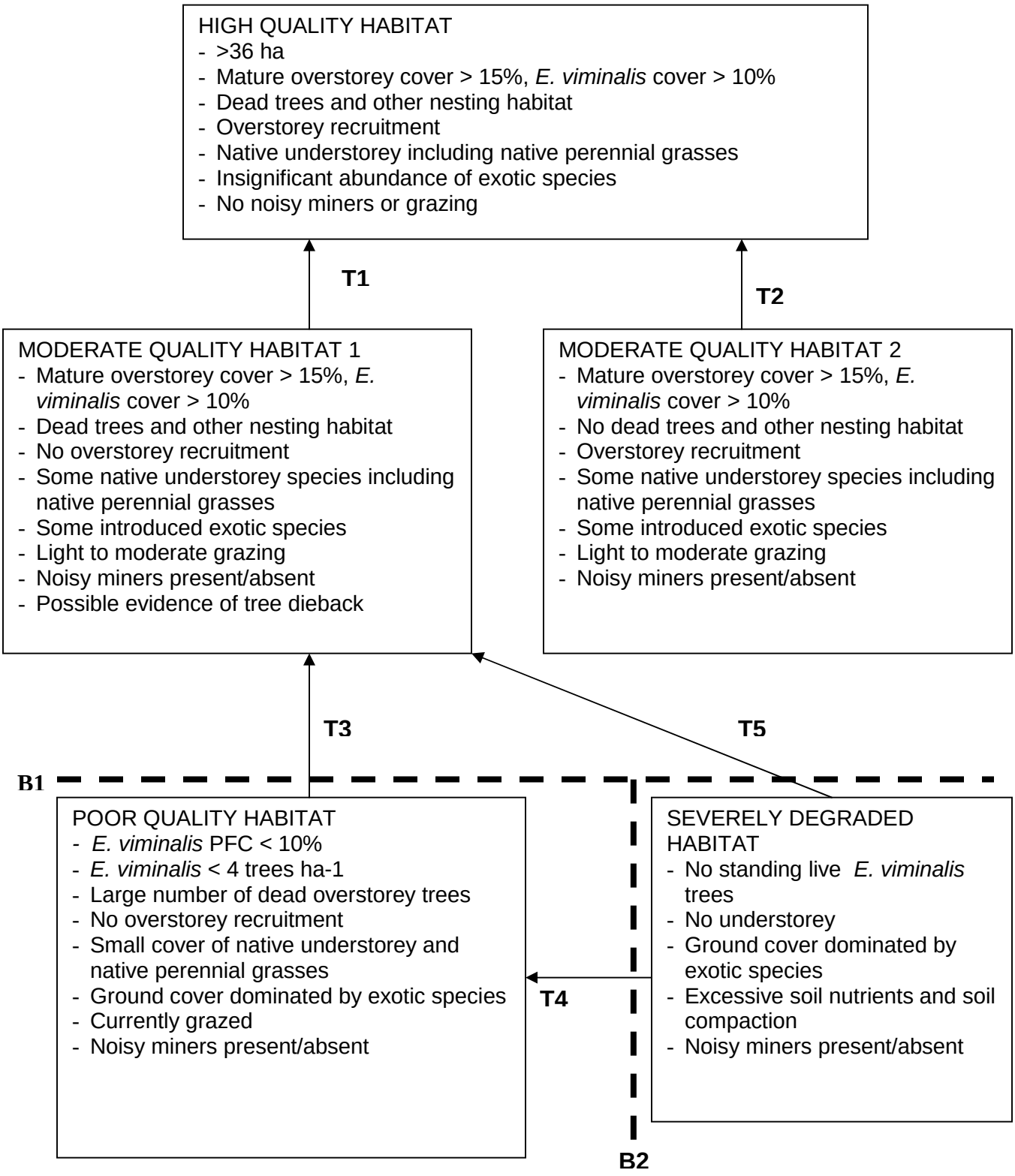

Figure 5. A state-and-transition model for the Forty-Spotted Pardalote. Five common habitat conditions are identified. Restoring habitat to a higher state requires management actions that allow a transition (T1 – T5) and overcoming ecological barriers (B1, B2).

Costs of restoration actions will be much higher for severely degraded habitat than for moderate quality habitat. The actions required to achieve a transition to a higher quality state are summarised in Table 3 along with the financial and labour costs associated with each transition relative to the other transitions. This Table emphasises that not only will restoring high quality habitat have greater benefits for the Forty-Spotted Pardalote, but it will also be less expensive and less onerous on land managers.

Table 3. Costs of actions associated with the state-and-transition model for the Forty-Spotted Pardalote.

	Actions	Relative cost
T1	Fencing, remove stock	Low
T2	Fencing, remove stock, adjoin with neighbouring dead trees, provision of logs	Low - Medium
T3	Ongoing weed control, scalping, establishing native perennial grasses, small scale revegetation	Medium – High
T4	Large scale revegetation	High
T5	Ongoing weed control, scalping, establishing native perennial grasses, large scale revegetation	Very High

Guidelines and Priorities for Habitat Restoration

Given the concerning decline in Forty-Spotted Pardalote numbers and the limited funding and resources available for habitat restoration, a set of guidelines are required to ensure on ground works are prioritized to optimize the benefit for the species. The following guidelines prioritise in order of importance, which colonies should be targeted for restoration based on the most recent population and habitat survey in 2009 (Bryant 2010):

1. Deteriorating habitat with existing colonies that have:
    a. Greater than 10 breeding birds.
    b. Less than 10 breeding birds.
2. Deteriorating habitat where colonies are no longer found but have in the past.
3. Deteriorating habitat where colonies have never been found but adjoin(s):
    a. Two or more existing colonies with greater than 10 breeding birds.
    b. An existing colony with greater than 10 breeding birds.
    c. Two or more existing colonies with less than 10 breeding birds.
    d. An existing colony with less than 10 breeding birds.

The colonies listed in Table 4 identify which colonies should be targeted according to the priorities 1a, 1b and 2.

Table 4. Restoration priorities for Forty-Spotted Pardalote colonies. Colony numbers follow Brown (1986).

Priority	Maria Island	Bruny Island	Tinderbox	Coningham	Taroona
1a		11, 24, 37			
1b	2, 5, 6, 19	1, 7, 12, 22, 36, 53, 61	3, 11	1	
2	3, 10, 21	2, 5, 6, 8, 15, 16, 18, 21, 26, 27, 28, 30, 31, 38, 39, 42, 43, 46, 47, 52, 69			1

Although Lime Bay satisfies category 2 it is not a priority due to distance from nearest pardalote dispersal source is too great.

Restoration priorities should also consider the landscape context for each colony. That is colonies with a closer proximity to larger feeder colonies should be prioritized over colonies of similar size but further from larger colonies.

Table 5 allocates the colonies listed in Table 2 into the five habitat states identified by the state-and-transition model. This will assist land managers in understanding the level of intervention, and time and costs, required to restore habitat. NB: bolded numbers satisfy more than one habitat state.

Table 5. Habitat state of Forty-Spotted Pardalote colonies prioritised for restoration. Colony numbers follow Brown (1986).

	Maria Island	Bruny Island	Tinderbox	Lime Bay	Coningham	Taroona
High Quality Habitat						
Moderate Quality Habitat 1	**2**, **5**, **10**	1, **2**, **7**, 11, 12, **16**, **22**, 24, 27, 30, 31, **36**, 37, 38, **39**, 53, 61, 65	3, 11	1, 2, 4	1	**1**
Moderate Quality Habitat 2	**2**, **5**, **10**	**2**, **7**, **16**, **22**, **36**, **39**				**1**
Poor Quality Habitat	19, 21	5, 8, 18, 21, 26, 47, 52				
Severely Degraded Habitat	6	15, 28, 42, 43, 46, 69				

Monitoring

The goal of this management plan is to improve habitat quality available to the Forty-Spotted Pardalote. It is anticipated that restored habitat will stabilise and possibly increase Forty-Spotted Pardalote numbers. The Threatened Species Section of the State Government has an ongoing monitoring program for the Forty-Spotted Pardalote and where possible Forty-Spotted Pardalote populations will be monitored where on-ground restoration is conducted. Success of habitat restoration will be gauged through ongoing monitoring of restoration sites using photo points and qualitative assessments of sites based on the key attributes of Forty-Spotted Pardalote habitat. A long term trial investigating the success of *E. viminalis* regeneration based on the suggested restoration techniques will be established with results used to refine ongoing restoration works. This trial will be undertaken in partnership with a range of stakeholders including other environmental organisations and will be carried out in a range of remnants characteristic of current Forty-Spotted Pardalote habitat.

References

Archibald, R. D., Craig, M. D., Bialkowski, K., Howe, C., Burgess, T. I. & Hardy, G. E. 2011. Managing small remnants of native forest to increase biodiversity within plantation landscapes in the south west of Western Australia, Forest Ecology and Management 261, 1254-1264.

Brereton , R., Bryant, S. L. & Rowell, M. 1997. Habitat modeling of the Forty-Spotted Pardalote and recommendations for management. Report to the Tasmanian RFA Environment and Heritage Technical Committee, Hobart.

Brown, P. B. 1986. The Forty-Spotted Pardalote in Tasmania. Technical Report 86/4. National Parks and Wildlife Service, Tasmania.

Bryant, S. L. 1991. The Forty-Spotted Pardalote Recovery Plan: management phase. Department of Parks, Wildlife and Heritage, Hobart.

Bryant, S. L. 1997. *The status of colonies of the Forty-Spotted Pardalote*. Tasmanian Bird Report 26, 45-51.

Bryant, S. L. 2010. Conservation assessment of the Forty-Spotted Pardalote 2009-2010. Report to Threatened Species Section, DPIPWE and NRM South, Hobart.

Bulman, C. M., Rounsevell, D. E. & Woinarski J. C. Z. 1986. The Forty-Spotted Pardalote RAOU Conservation Statement. RAOU Report No. 17. Melbourne RAOU.

Clark, M. F. & Oldland, J. M. 2007. *Penetration of remnant edges by noisy miners (Manorina melanocephala*) *and implications for habitat restoration*. Wildlife Research 34, 253-261.

Clarke, P. J. & Davison, E. A. 2001. *Experiments on the mechanism of tree and shrub establishment in temperate grassy woodlands: seedling emergence*. Austral Ecology 26, 400-412.

Close, D. C. & Davidson, N. J. 2002. *Revegetation to combat tree decline in the Midlands and Derwent Valley Lowlands of Tasmania: practices for improved plant establishment*. Ecological Management and Restoration 4, 29-36.

Close, D. C., Davidson, N. J. & Watson, T. 2008. *Health of remnant woodlands in fragments under distinct grazing regimes*. Biological Conservation 141, 2395-2402.

Close, D. C., Davidson, N. J., Churchill, K. C. & Corkrey, R. 2010. *Establishment of native Eucalyptus pauciflora* and exotic *Eucalyptus nitens* on former grazing land. New Forests 40, 143-152.

Davidson, N. J., Close, D. C., Battaglia, M.,Churchill, K., Ottenschlaeger, M., Watson, T. & Bruce, J. 2007. *Eucalypt health and agricultural land management within bushland remnants in the Midlands of Tasmania, Australia*. Biological Conservation 139, 439-446.

DEWHA 2008. Threat abatement plan for predation by feral cats. Department of the Environment, Water, Heritage and the Arts, Biodiversity Conservation Branch, Commonwealth of Australia, Canberra.

Dooley, G. M., Murray, M. D., Lutze, M. T., McCarthy, G. J., Perry, P. C. & Fagg, P. C. 2010. *Seedcrop development in Eucalyptus viminalis in High-Elevation Mixed Species forest of East Gippsland.* Australian Forestry 73, 24-33.

Dorr, T. L. 1999. Foraging behaviour and habitat selection of the Forty-Spotted Pardalote *Pardalotus quadragintus*. Unpublished Hons Thesis. Department of Zoology, University of Tasmania, Hobart.

Dorrough, J. & Moxham, C. 2005. *Eucalypt establishment in agricultural landscapes and implications for landscape-scale restoration*. Biological Conservation 123, 55-66.

Fischer, J., Stott, J., Zerger, A., Warren, G., Sherren, K. & Forrester, R. I. 2009. *Reversing a tree regeneration crisis in an endangered ecoregion*, Proceedings of the National Academy of Sciences 106, 10386-10391

Gibson-Roy, P., Moore, G. & Delpratt, J. 2010. *Testing methods for reducing weed loads in preparation for reconstructing species-rich native grassland by direct seeding*. Ecological Management and Restoration 11, 135-139.

Hastings, R. A. & Beattie, A. J. 2006. *Stop the bullying in the corridors: can including shrubs make you revegetation more Noisy Miner free?* Ecological Management and Restoration 7, 105-112.

Ilijima, C. 2010. Extent and quality of habitat for the endangered Forty-Spotted Pardalote (*Pardalotus quadragintus*) at Howden, Tasmania. Unpublished MSc Thesis. Department of Geography. University of Tasmania.

MacDonald, M. A. & Kirkpatrick, J. B. 2003. *Explaining bird species composition and richness in eucalypt-dominated remnants in subhumid Tasmania.* Journal of Biogeography 30, 1415-1426.

Major, R. E., Christie, F. J. & Gowing, G. 2001, *Influence of remnant and landscape attributes on Australian woodland bird communities*, Biological Conservation 102, 47-66.

Maron, M. 2007. *Threshold effect of eucalypt density on an aggressive avian competitor*. Biological Conservation 136, 100-107.

Maron, M., Main, A., Bowen, M., Howes, A., Kath, J., Pillete, C. and McAlpine, C. A. 2011. *Relative influence of habitat modification and interspecific competition on woodland bird assemblages in eastern Australia*. Emu 111, 40-51.

Piper, S. D. & Catterall, C. P. *A particular case and a general pattern: hyperaggressive behaviour by one species may mediate avifaunal decrease in fragmented Australia forests.* Oikos, 101, 602-614.

Prober, S. M., Thiele, K. R., Lunt, I. D. & Koen, T. B. 2005. *Restoring ecological function in temperate grassy woodlands: manipulating soil nutrient, exotic annuals and native perennial grasses through carbon supplements and spring burns*. Journal of Applied Ecology 42, 1073-1085.

Prober, S. M., Lunt, I. D. & Thiele, K. R. 2008. *Effects of fire frequency and mowing in a temperate, derived grassland soil in south-eastern Australia.* International Journal of Wildland Fire 17, 586-594.

Prober, S. M. & Lunt, I. D. 2009. *Restoration of Themeda australis swards suppresses soil nitrate and enhances ecological resistance to invasion by exotic annuals.* Biological Invasions 11, 171-181.

Spooner, P. G. & Briggs, S. V. 2006. *Woodlands on farms in southern New South Wales: a longer-term assessment of vegetation changes after fencing.* Ecological Management and Restoration 9, 33-41.

Taylor, R. S., Oldland, J. M. & Clarke, M. F. 2008. *Edge geometry influences patch-level habitat use by an edge specialist in south-eastern Australia*, Landscape Ecology 23, 377-389.

Thomas, R. 2009. *Regent Honeyeater Habitat Restoration Project Lurg Hills, Victoria.* Ecological Management and Restoration 10, 84-97.

Threatened Species Section 2005. Tasmania's NRM Threatened Species Program 2004-2005 Final Report. Department of Primary Industries and Water, Hobart.

Threatened Species Section 2006. Fauna Recovery Plan: Forty-Spotted Pardalote 2006-2010. Department of Primary Industries and Water, Hobart.

Threatened Species Unit 1998. Fauna Recovery Plan: Forty-Spotted Pardalote *Pardalotus quadragintus*. Parks and Wildlife Service, Tasmania.

Vesk, P. A., Nolan, R., Thomson, J. R., Dorrough, J. W. & Mac Nally, R. 2008. *Time lags in provision of habitat resources through revegetation*. Biological Conservation 141, 174-186.

Watson, D. M, 2011. *A productivity-based explanation for woodland bird declines: poorer soils yield less food*. Emu 111, 10-18.

Weinberg, A., Gibbons, P., Briggs, S. V. & Bonser, S. P. 2011. *The extent and pattern of Eucalyptus regeneration in an agricultural landscape.* Biological Conservation 144, 227-233.

Wills, T. J. & Read, J. 2002. *Effects of heat and smoke on germination of soil-stored seed in a south-eastern Australian sand heathland*. Australian Journal of Botany 50, 197-206.

Woinarski, J. C. Z. & Bulman, C. 1985. *Ecology and breeding biology of the Forty-Spotted Pardalote and other pardalotes on north Bruny Island.* Emu 85, 106-120.

Woinarski, J. C. Z. & Roundsevell, D. E. 1983. *Comparative ecology of pardalotes, including the Forty-Spotted Pardalote, Pardalotus quadragintus (Aves: Pardalotidae) in south-eastern Tasmania*. Australian Wildlife Research 10, 351-361.

Yates, C. J., Norton, D. A. & Hobbs, R. J. 2000. *Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration*. Austral Ecology 25, 36-47.