The importance of adaptive management in 'off-reserve' conservation for forest fauna: implementing, monitoring and upgrading Swift Parrot *Lathamus discolor* conservation measures in Tasmania

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ABSTRACT

As formal reservation targets are attained in Tasmania, a large component of habitats important for populations of threatened fauna will remain in the 'off-reserve' landscape. Over eighty percent of Swift Parrot *Lathamus discolor* foraging habitat occurs on private land, potentially subject to production forestry or agriculture. As a first step in monitoring the effectiveness of management prescriptions for the conservation of swift parrot foraging habitat in 'off-reserve' areas, an assessment was made of their implementation in 57 forestry operations conducted between February 1995 and March 1998. Prescriptions advised by specialists were generally incorporated into timber harvesting plans. However, post-harvest assessment of 10 operation areas (nine on private and one on State forest) containing high or medium quality habitat suggested that implementation of prescriptions on the ground was not effective in capturing foraging habitat. Although the prescribed clumps of trees were retained in all operation areas, and all clumps included some *Eucalyptus globulus,* only 16 percent of clumps surveyed contained the prescribed number of prime foraging trees (2-3 mature *E. globulus*). In part, this was thought to be due to the low level of detail in the plans describing how contractors, responsible for the timber harvesting, should implement the prescriptions. However, comparison with the composition of 'control' clumps retained in adjacent intact forest suggested that clump retention was an inappropriate prescription for most of the operation areas on private land, where forage trees were sparsely distributed. Where clumps of foraging habitat were retained, there was substantial post-harvest disturbance bringing into question the long-term effectiveness of such prescriptions even when correctly applied in forestry operations. As a result of this work, the swift parrot prescriptions were modified to better achieve retention of foraging habitat through the adoption of a patch retention strategy. In addition, steps were taken to improve standards of implementation by foresters and contractors. These included more intense training for foresters and the development of planning tools to clarify and simplify prescriptions. Importantly, recent legislative changes have provided an instrument to potentially achieve long-term conservation of retained habitat on private land.

Key words: swift parrot, threatened species, forestry, implementation monitoring.

Introduction

The contribution of Tasmania's Comprehensive, Adequate and Representative (CAR) reserve system to the conservation of the State's fauna diversity is significant. However, conservation in areas outside reserves, covering all land tenures and at every spatial scale, needs to be encouraged because many species, particularly threatened species, remain poorly reserved (Taylor 1991; DPIWE 2001). 'Off-reserve' conservation management by prescription has developed in principle since the late 1970s and is currently the primary mechanism for conservation of many threatened fauna species in Tasmania. Management objectives, prescriptions and planning processes have been developed to cater for threatened fauna in 'off-reserve' areas subject to forestry activities (Jackson and Taylor 1994; Munks and Taylor 2000; Forest Practices Board 2001a, b; 2002). To be effective, such conservation measures need to be complemented by a high standard of planning and implementation. Ultimately, to ensure that they are achieving conservation outcomes for the species, their adequacy needs to be continually monitored via auditing and further research.

The annual audit of forestry operations, carried out by the agency responsible for the administration of the Tasmanian forest practices system (Forest Practices Board 2000a), records some data on the implementation of forest fauna conservation measures in Tasmania. However, this audit attempts to monitor a broad range of provisions required under the *Forest Practices Act 1985,* and therefore the sample size and level of detail is often not sufficient to assess implementation of a particular conservation prescription.

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A few studies have evaluated in detail the effectiveness of some of the fauna conservation measures in achieving objectives for particular species (e.g. Mooney and Taylor 1996; Mooney 2000; Macdonald *et al*. 2001). However, the effectiveness of most measures, particularly in achieving objectives on private land, remains to be evaluated.

The Swift Parrot *Lathamus discolor* is listed as Endangered under the Tasmanian *Threatened Species Protection Act 1995,* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and as a priority species under the *Tasmanian Regional Forest Agreement* (Commonwealth of Australia and State of Tasmania 1997). It breeds only in Tasmania and migrates to mainland Australia in autumn. Nesting areas are usually on the upper slopes and ridges. It nests in tree hollows in mostly shrubby Brown-top stringybark *Eucalyptus obliqua* or White-top stringybark *Eucalyptus delegatensis* forest in eastern Tasmania (Brown 1989; Brereton 1997). Foraging areas are predominantly in grassy Tasmanian Blue Gum *Eucalyptus globulus* forest where they feed on the nectar of the Blue Gum flowers (Brereton 1997). This forest type has a patchy distribution in eastern Tasmania, related to slope, aspect, available moisture and soil depth. Within the forest patches, birds actively select larger trees (mean dbh 37-140 cm) for foraging (Brereton 1997; Brereton *et al.* in press). Shrubby Swamp Gum *Eucalyptus ovata* forest is an important food resource early in the breeding season, as well as in the years when the flowering of Blue Gum is poor (Brown 1989; Brereton 1997). Potential Swift Parrot foraging habitat covers an area of approximately 8,000 ha (Swift Parrot Recovery Team 2001) with 82% (6,700 ha) occurring on private land and 18% (1,000 ha) in CAR reserves.

Woodlands and forests within the parrot's over-wintering range and the Blue Gum forests within its restricted breeding distribution have been fragmented and substantially reduced by land clearance for agriculture and urban development (Brereton 1997). In addition, forestry operations and firewood collection are altering the age structure of forests, resulting in the loss of older trees that provide a substantial food resource as well as hollows for nesting. In Tasmania, management prescriptions for the conservation of Swift Parrot habitat in areas subject to production forestry operations, on both private and public land, were developed in April 1994 for inclusion in the first edition of the Forest Practices Board's *Threatened Fauna Manual* (Jackson and Taylor 1994). These prescriptions were originally formulated in the implementation of the *Swift Parrot Recovery Plan: Research Phase* (Gaffney and Brown 1992) and were based on limited information. The prescriptions for the conservation management of foraging habitat were targeted at the local harvesting unit level (generally 50-100 ha). They aimed to retain a proportion of the mature trees (prime foraging trees) within harvest areas and to ensure the maintenance and redevelopment of such trees over successive cutting cycles. The ultimate aim was to assist the maintenance of viable swift parrot populations across their range. Different levels of retention were prescribed depending on the quality of the habitat as assessed by trained foresters and/or specialist zoologists.

Following the introduction of the Swift Parrot prescriptions, anecdotal reports from foresters suggested some confusion as to how they should be implemented and that in some forest types they may not be effective in retaining foraging trees. To investigate these reports, monitoring and evaluation of these 'off-reserve' management prescriptions commenced in 1998 (Brereton 1998). This monitoring was part of a broader program to assess the performance of all threatened fauna conservation measures in Tasmania's production forests. This paper presents the results of an essential part of the monitoring program for the Swift Parrot, particularly a detailed evaluation of the implementation of the prescriptions for the conservation of Swift Parrot foraging habitat in areas subject to forestry operations, predominantly on private land. Both the application of the prescriptions during the planning of forestry operations, and their implementation in the harvest area, were assessed. The subsequent upgrading of the Swift Parrot conservation measures (Hobbs and Saunders, 2000) is also discussed.

Methods

The study was divided into two parts: assessment of the application of actions prescribed by specialists in timber harvesting plans and; assessment of implementation of the prescriptions in the harvest areas.

Assessing of the application of prescriptions in plans

Selection of timber harvesting plans

In the development of a plan for a proposed forestry operation in Tasmania (timber harvesting plan), forest officers are required to seek advice from specialists if the proposed operation area is likely to contain habitat of species listed in the schedules of the *Tasmanian Threatened Species Protection Act 1995* (Munks and Taylor 2000). Records of these 'advice requests', and the prescriptions advised by a specialist for a particular operation, are maintained in a database managed by the Forest Practices Board. Consultation of this database revealed that 83 timber harvesting plans, for areas within potential Swift Parrot habitat, were prepared between 1995 and 1998, i.e. the year the Swift Parrot prescriptions were introduced and the commencement of the monitoring program.

Fifty-seven of these plans, and associated records of advice provided by the specialist, were selected for assessment. The excluded plans included those where the proposed operation did not go ahead (12), those where no plan was readily available (4), those that related to road construction operations only (3) and those that were for operations within the range of nesting areas rather than foraging habitat (7).

Information obtained from the plans

Information considered important for assessing the application of conservation measures during the planning of forestry operations, and for informing improved performance, was derived from the timber harvesting plans and associated documentation. This information

included: the forestry organisation preparing the timber harvesting plan; land tenure (private or State); proposed harvest area (ha); harvest method; and the quality of Swift Parrot foraging habitat in the proposed operation area (i.e. low, medium, high). The categories of habitat within the harvest area were determined from information provided in the plans and were based on definitions in Jackson & Taylor (1994) and Brereton (1997) as follows:

High – coastal dry sclerophyll forest (within 10 km of the coast) with Blue Gum greater than 30% of canopy species;

Medium – dry sclerophyll forest with Blue Gum greater than 10% and less than 30% canopy species;

Low – other occurrences of Blue Gum, including wet sclerophyll forest.

Information on the number of plans for which specialists provided advice could only be derived from 37 of the 57 plans. The remaining plans did not have complete associated documentation (e.g. survey reports, records of specialist advice). Details of the types of prescriptions advised by specialists are presented in Table 1. Information on the adequacy of the interpretation of the specialists advice into timber harvesting plan was recorded for 21 plans, for areas identified during pre-logging surveys, by forest planners or the species specialists, as having medium to high quality Swift Parrot foraging habitat.

Assessing the implementation of prescriptions in harvest areas

Selection of harvest areas

Ten of the 21 plans for areas of medium or high quality habitat were selected randomly for a post-logging assessment of the implementation of the conservation prescriptions in operation areas. Seven of these selected operations were within 5 km of the coast, while three operation areas were located near the township of Buckland, where Swift Parrots are known to forage further inland (Brereton 1997). All operations, apart from one on State forest (operation 17), occurred on private land, in an area covering approximately 200 km of coastline, ranging from Falmouth in the State's north-east, to Kellevie, in the south-east (Fig. 1).

Since the medium and high quality Swift Parrot habitat has a patchy distribution, and the study was restricted to harvesting operations conducted within a limited time period, sites were not evenly distributed across the foraging range of the Swift Parrot. Hence, the majority of sites was clustered in south-east Tasmania. All operation areas selected were logged after 1997 and, apart from one, each was selectively harvested (Table 1, see Wilkinson, 1993 for detailed descriptions of silvicultural methods). Retention of small clumps of forage trees across the operation area formed the main prescription (categories

Table 1. Actions prescribed by specialists for the conservation of swift parrot foraging habitat (derived from 37 plans) and the number of timber harvesting plans, for areas with medium and high quality foraging habitat (21 plans), in which the prescription was applied.

Conservation prescription	Description	No. of Timber harvesting plans*	
		Moderate quality habitat	High quality habitat
1) Wildlife habitat clump	Retention of clumps of blue gum at a rate of 1/5 ha. Clumps to contain 2-3 habitat trees** and a mix of ages of regrowth.	3	3
2) Wildlife habitat clump	Retention of clumps of blue gum at a rate of 2/5 ha. Clumps to contain 2-3 habitat trees** and a mix of ages of regrowth.	0	0
3) Standard Wildlife habitat clump	Retention of clumps of blue gum at a rate of 2/5 ha where blue gum constitutes > 30% of canopy species and at a rate of 1/5 ha in other areas of blue gum. Clumps to contain 2-3 habitat trees** and a mix of ages of regrowth.	2	2
4) Patch	The exclusion of a specific area of blue gum greater in size than a standard clump as in 1.,2.,and 3., from the proposed harvest operation.	4	4
5) Single	The retention of single specimens of blue gum of a variety of ages (but including old-growth habitat trees**) across the proposed harvest area.	1	1
6) WHC1/Other	A combination of 1. & 4. or 5.	4	4
7) WHC2/Other	A combination of 2. & 4. or 5.	1	1

*More than one prescription was occasionally advised for a particular operation area where both medium and high quality habitat was present.

**Habitat trees are defined as mature trees with hollows (Forestry Commission, 1993). Generally *E. globulus* habitat trees will be greater than 37cm dbh to meet the definition of a prime forage tree for the swift parrot (Brereton 1997).

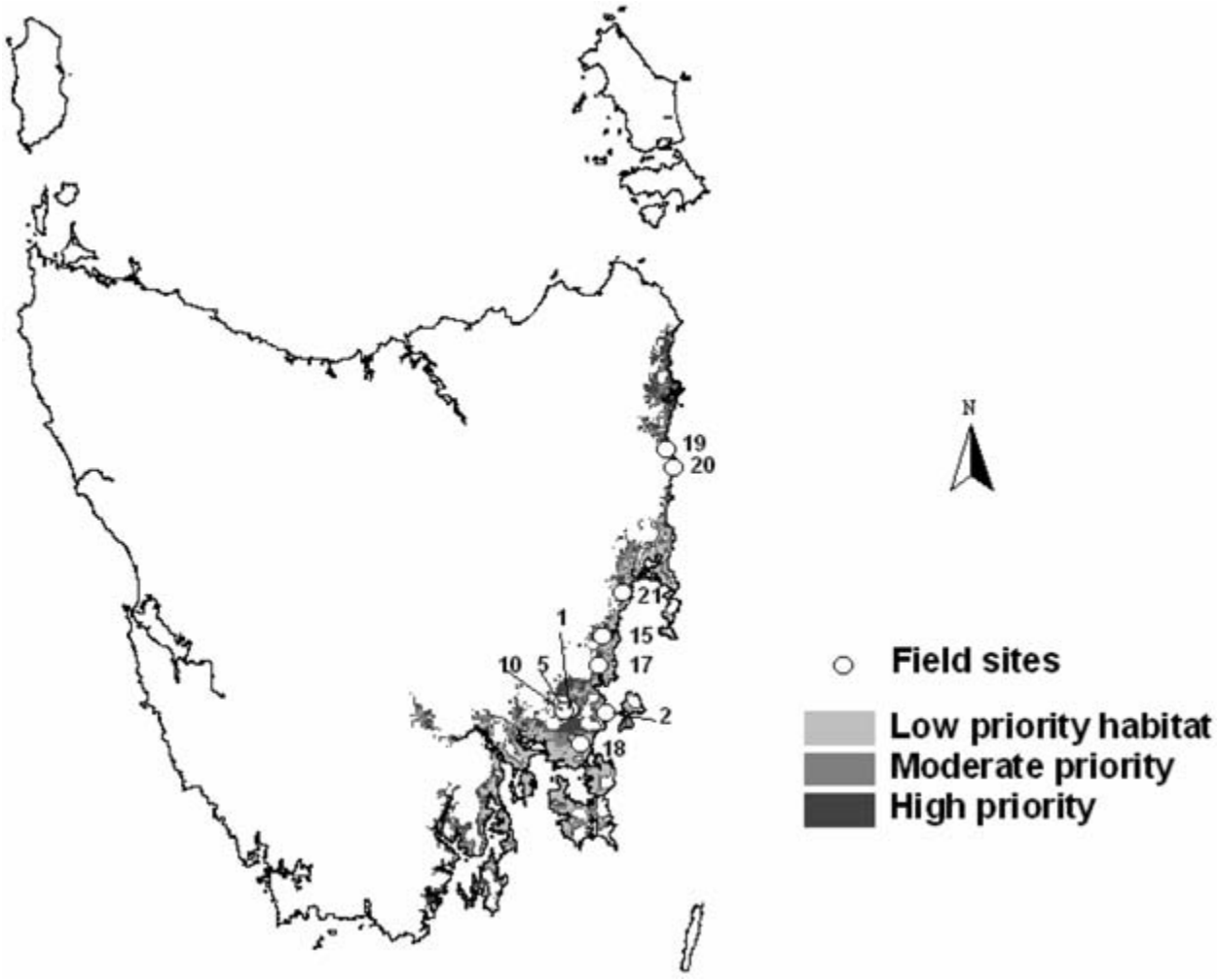

Figure 1. Location of forestry operations surveyed, and distribution of swift parrot foraging habitat.

1,2 and 3; Table 1 and 2) advised by specialists for all 10 operation areas. In five of the timber harvesting plans, patch or single tree retention (categories 6 and 7, Table 1 and 2), was also advised.

Survey of harvest areas

The number of clumps of trees retained in four of the operation areas (21, 15, 2, 18, Table 2) was compared, during field surveys conducted between March and June 1999, with the number specified in the corresponding timber harvesting plan. In the forest regenerating after harvest, the difficulty of locating all the clumps, prevented the collection of data in two of the harvest areas. The number of clumps of trees required was not specified in the timber harvesting plans for the remaining four operations.

Information on clump size and composition was obtained for two to four randomly selected clumps in each of the 10 harvest areas. Information collected included: diameter (m) and area (ha) of retained clump; number of habitat trees; diameter at breast height (dbh in cm) for *Eucalyptus* species; number of Swift Parrot forage trees (*E. globulus* > 37cm dbh); ground cover (rock cover, scale 1-5, where 1 = low and 5 = high). A subjective measure of disturbance (on a scale between 1 and 5) to the retained clumps of trees was also collected; 1 referred to undisturbed clumps, and 5 represented retained clumps with very little remaining ground cover and evidence of fire, mechanical disturbance, grazing, or dumping of logging slash.

In each of the 10 harvest areas, three to five retained clumps were selected randomly and the vegetation structure and floristics of each clump were recorded as per Brereton (1997) using TASFORHAB (Peters 1983). For 9 of the 10 harvest areas, the vegetation structure and floristics, number of Swift Parrot forage trees (*E. globulus* or *E. ovata* > 37cm dbh) and habitat trees were also recorded in three 'control clumps' of a similar diameter randomly selected in adjacent intact forest (Table 2).

Data analyses

Two-way ANOVA, with site nested in treatment (i.e. logged and control) was used to compare the diameter at breast height (dbh) of *E. globulus* for retained clumps and control clumps, and the number of Swift Parrot foraging trees in retained clumps and control clumps. A three-way ANOVA, with site nested within treatment was used to compare the diameter class distributions of *E.* globulus in retained clumps and control clumps. Data were log-transformed where necessary to meet the assumptions of ANOVA. Levels of statistical significance were set at 0.05.

The vegetation structure and floristics data of each treatment were analysed for similarity using PATN 4.0 (Belbin 1995) between treatments and with data from known high quality Swift Parrot foraging sites that had been collected by Brereton (1997) following the same sampling methods used in this study. Three treatments are represented in the analyses: 1. Retained clumps (wildlife habitat clumps, WHC); 2. Adjacent intact forest (control clumps) and 3. High priority habitat. Due to a discrepancy in the technique used to determine the percentage cover of the understorey vegetation between this study and Brereton (1997), this variable was excluded from the analyses.

A total of three combinations of treatments was analysed: (i) All three treatments, (ii) Retained clumps and high quality habitat; and (iii) Retained clumps and control clumps. Algorithms used by Brereton (1997) were applied to vegetation height-class and percentage cover data to convert them to values. For each analysis, the data were log-transformed. All datasets were MASKed to remove rare data (five or less occurrences). Classification analysis was conducted with each dataset treatment using the Bray-Curtis dissociation measure, which explored the relationship amongst variables. To provide an enhanced (sharper) group structure for species clustering, β was set at $\beta = -0.25$. Default, semi-strong hybrid multidimensional scaling was applied to the datasets for the ordination analyses. Principal Components Analysis (PCA) was also conducted. Monte-Carlo attributes and ordination (MCAO) were used to identify any flora species having a significant influence on the analyses.

Results

Disturbance of foraging habitat by forestry operations

The 57 timber harvesting plans for operation areas, that were identified as having potential Swift Parrot habitat, encompassed 3,971 ha of native forest. Pre-logging surveys confirmed high quality Swift Parrot foraging habitat in 22% (882 ha) of the total forest area covered by the plans (Table 3). A further 55% of the plans (2,182 ha) were found to contain medium quality habitat. Only 2% of the forest area covered by the plans was found to contain no potential foraging habitat. A comparison, in an operation area, of the reporting of potential Swift Parrot foraging habitat (high, medium, low or unsuitable) by forest officers with that of the species specialist revealed that, in general, habitat was well identified by the forest officers. In only 3 of the 57 plans did specialists subsequently report the occurrence of potential habitat, identified by forest officers, as unsuitable habitat.

Table 2. Details of operation areas surveyed and characteristics of clumps of trees retained in each operation area as prescribed in the Timber Harvesting Plan. (# = no data). CLF = Clearfall; CLR/SEL = Mix of clearfall with retention & selective; AGR = Advanced growth retention; SEL = Selective; SED = Seed tree retention.

Operation area no.	Location	Planned harvest area (ha)	Harvest method	Planned future use	Swift parrot prescription*	No. WHCs surveyed	Clumps with 2-3 E.globulus habitat** trees (swift parrot forage trees)	Clumps with one E.globulus habitat** tree.	Control clumps (n)	Control clumps with 2-3 E.globulus habitat** trees	Control clumps with 1 E.globulus habitat** tree
19	Falmouth	15	SED	Native forest	3	2	0	0	1	0	1
20	Inglewood	65	SED	Native forest	7	3	1	0	3	1	2
21	Swansea	197	SED	Native forest	2	4	0	1	3	1	0
15	Swanston	176	CLR/SEL	Agriculture	6	3	0	1	4	1	0
17	Swanport	67	SED	Native forest	6	3	1	2	3	0	0
5	Sally Peak	105	AGR/SED	Native forest	6	3	0	0	2	0	1
2	Ringrove, Wielangta	41	CLF	Agriculture	1	3	0	1	3	0	2
1	Buckland A	168.7	SEL	Native forest	1	4	1	2	2	0	1
10	Buckland B	88	SED	Native forest	6	3	1	1	2	0	2
18	Kellevie	21	SED	Native forest	2	3	1	0	#	#	#
Total						31	5 (16.13%)	8 (26%)	23	3 (13.04%)	9(39.1%)

*See Table 1 for description. ** Mature trees with hollows (Forestry Commission 1993). Generally habitat trees will be greater than 37cmdbh to meet the definition of a prime forage tree for the swift parrot (Brereton 1997).

Table 3. Harvest areas (hectares) and methods used within the different priority categories of swift parrot foraging habitat (CLF = Clearfall; CLF/SEL = Mix of clearfall & selective; SEL = Selective; SED = Seed tree retention).

Habitat quality	Timber Harvesting Plans	Harvest method (area in hectares)				Total Harvest Area (ha)
		CLF	CLF/SEL	SEL	SED	
Unsuitable	3	10	46	35	0	91
LOW	19	660*	21	0	135	816
MOD	26	119	386	1,042	635	2,182
HIGH	9	43	455	107	277	882
TOTAL	57	832	908	1,184	1,047	3,971

*= one record for which no harvest area was indicated.

The overwhelming majority of the 57 plans (91%) was for operations on private land. Most of the forest area was subject to partial harvesting systems (2,231 ha), with the remainder subject to either a combination of partial and clearfell harvesting or clearfelling only. Sixty-seven percent (2,672 ha) of the forest area was proposed for regeneration to native forest after harvesting. Approximately 25% (1,000 ha) was proposed for clearance of native forest for agriculture, grazing, or the establishment of eucalypt and pine plantations.

The bulk of the forest containing medium and high quality foraging habitat was harvested using partial harvesting systems (67%), with only 5% subject to clearfelling (Table 3). Seventy-one percent (2,167 ha) of this forest was to be regenerated to native forest, while 23% was proposed for other land uses, such as agriculture or establishment of eucalypt plantations. Of the 882 ha of forest found to contain high quality Swift Parrot foraging habitat, 48% (427 ha) was proposed for regeneration to native forest, 45% (396 ha) for agriculture, and 7% (59 ha) for conversion to eucalypt plantation.

Application of prescriptions in plans

Specialists provided advice, with complete documentation, for 24 of the 37 plans for operations in low (3), moderate (9) and high (12) priority Swift Parrot foraging habitat. Nine of the remaining plans were considered by specialists to be unsuitable habitat, or of insufficient habitat quality to warrant additional conservation measures. In two plans, existing reserves adjacent to the proposed operation area were considered sufficient for the conservation of Swift Parrot foraging habitat, and in another two the partial harvesting system proposed was considered little threat to the maintenance of forage trees.

The types of management prescriptions advised by specialists for the 21 proposed operations within medium and high quality habitat are presented in Table 1. More than one prescription was occasionally advised for a particular operation. The two most frequently advised prescriptions were patch retention (22%), and a combination of wildlife habitat clump retention and patch or single tree retention (39%) (Table 1). There was no pattern in the relationship between the type of prescribed action and the proposed harvesting method or proposed future land-use.

With three exceptions, specialist advice was fully incorporated into the relevant sections of the 21 timber harvesting plans for areas of medium and high quality foraging habitat (Table 4). All 21 timber harvesting plans stipulated that retained patches or clumps were to target blue gum, and where wildlife habitat clumps were prescribed, all but one specified the rate of retention across the operation area. However, only five of the timber harvesting plans included a description of a Swift Parrot foraging tree (i.e. the type of blue gum tree that should be targeted for retention). This description was only included in plans when it was specified in written advice from the specialist. None of the timber harvesting plans made the distinction between the retention of Swift Parrot foraging trees within clumps, and the retention of hollow-bearing habitat trees required by a general wildlife provision in the Forest Practices Code (Forestry Commission 1993).

Information on the location of potential foraging habitat was not displayed sufficiently on the timber harvesting plan maps. Only five of the timber harvesting plan maps delineated areas of high or medium quality Swift Parrot foraging habitat (Table 4). Similarly, although clumps of trees were prescribed in 16 of the plans, the desired location for the clumps, important to assist contractors responsible for implementing the prescriptions, was only indicated on a map of 10 of the plans (Table 4).

Implementation of prescriptions in the operation areas

Clumps of trees (average diameter of 49 m), as prescribed by the specialist (Table 2), were retained in all the 10 operation areas surveyed. Of the four operation areas, where the number of clumps specified in the plan was compared with the number of clumps of trees retained, three had the correct number of clumps (Table 2). In the fourth (number 15, Table 1), 19 clumps were specified in the timber harvesting plan, but only 16 clumps were retained.

Only 16% (5) of the clumps surveyed across the 10 operation areas contained 2-3 blue gum habitat trees (i.e. mature *E. globulus* greater than 37cm dbh with hollows) and a mix of ages of regrowth *E. globulus* as per the prescription advised by the specialist (Table 1). This was marginally higher than in the 'control' areas where only

Table 4. Standard of incorporation of specialists advice for 21 timber harvesting plans for operations in medium (M) and high (H) quality swift parrot (SP) foraging habitat and level of detail provided in the plan.

N/A = prescription category 4 or 5 advised.* As per prescription 1,2,3,6 or 7 (see Table 1 for definition).

THP No.	Location	Swift parrot habitat quality in coupe	Incorporation of specialists advice in the plan	Plan states rate of retention of clumps of trees*	Plan states targeting E.globulus	Swift parrot foraging tree described in Plan	Areas of good habitat indicated on plan map	Clumps of trees* indicated on plan map
1	Buckland A	M	Full	Y	Y	N	N	Y
2	Ringrove, Weilangta	M	Full	Y	Y	N	N	Y
3	Murdunna	M	Full	Y	Y	Y	N	Y
4	Knocklofty	M	Full	N/A	Y	Y	N	N/A
5	Sally Peak	H	Full	N	Y	N	N	Y
6	Chain of Lagoons	M	Full	Y	Y	N	N	N
7	Dublin Town	H	Full	Y	Y	N	N	N
8	Black Charlies	M	Full	N/A	Y	N	N	N/A
9	Nugent	H	Full	Y	Y	N	N	Y
10	Buckland B	H	Full	Y	Y	Y	N	N
11	UPI 0300 and 0071	M	Full	N/A	Y	N	Y	N/A
12	Mt Calvary	H	Part	Y	Y	N	N	N
13	Newmans Creek A	H	Full	Y	Y	N	Y	Y
14	Newmans Creek B	M	Full	Y	Y	N	Y	Y
15	Swanston	H	Full	Y	Y	Y	Y	Y
16	Ashgrove	H	Full	Y	Y	Y	Y	Y
17	Swanport	H	Full	Y	Y	N	N	N
18	Kellevie	H	Full	Y	Y	N	N	Y
19	Falmouth	H	Part	Y	Y	N	N	N
20	Inglewood	M	Part	Y	Y	N	N	N
21	Swansea	H	Full	N	Y	N	N	Y

13% of clumps marked out by a specialist had 2-3 Blue Gum habitat trees (Table 1). In contrast, the percentage of clumps of trees, containing at least one Blue Gum habitat tree, was higher in the 'control' clumps than in the operation areas (39% and 26%, respectively, Table 1). Only two of the 31 clumps, surveyed across all 10 operation areas, contained 2-3 habitat trees other than Blue Gum (i.e. mature eucalypt greater than 37 cm dbh with hollows), which suggested that other eucalypt species were not being selected instead of Blue Gums to meet the habitat tree requirement (Table 1).

Classification and ordination analysis revealed that, in most cases, the vegetation structure and floristic composition of the clumps of trees retained in the operation area, and the clumps of trees in the 'control' area, were similar. It was apparent that groupings occurred according to species composition and height class of eucalypts, rather than percentage composition. With the exception of operation area number 17 on State forest (Figure 1, Table 2), none of the logged or control clumps were grouped with the high quality foraging sites from Brereton (1997). Principal Components Analysis indicated that the differences between known high quality sites from Brereton (1997), and sites surveyed in this study, were due to differing height classes of *E. globulus* and the presence or absence of height classes of Silver Wattle *Acacia dealbata* and White Peppermint *E. pulchella*. In general, *E. globulus* trees were smaller, and there was a higher proportion of Silver Wattle *A. dealbata* and White Peppermint *E. pulchella* trees, at the sites in this study.

There was no significant difference between the mean diameter of Blue Gum trees occurring in the logged (43.2 ± 1.9 cm) and control clumps (50.5 ± 1.9 cm). There was, however, a significant difference between operation areas ($F_{16,1}$ = 12.47501; p = 0.0000), with operation area 10 (Buckland B) and 19 (Kellevie) varying greatly from the other seven operation areas (Figure 2). Operation area number 10 was assessed as having high quality habitat before harvest. The mean size of Blue Gum trees in the clumps in the logged area was consistent with this assessment. However, the mean size of Blue Gum in the 'control' clumps was indicative of a low habitat quality site. Operation area number 19 was also assessed as a high quality site before harvest. In contrast to operation area number 10, the mean size of Blue Gum in the clumps in the logged area was less than would be expected in high quality habitat, whereas in the 'control' clump, the retained trees indicated high quality habitat.

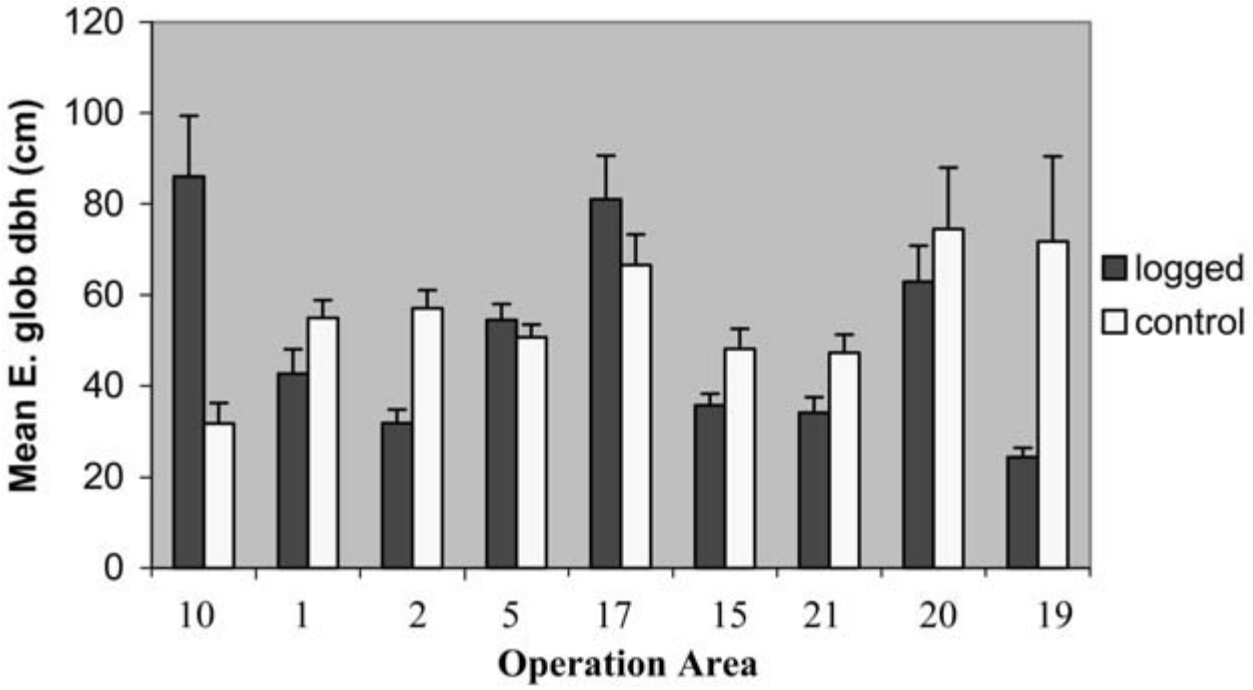

Figure 2. The diameter at breast height of Blue Gum *E. globulus,* in clumps retained in the operation areas and in 'control' clumps (mean ± se).

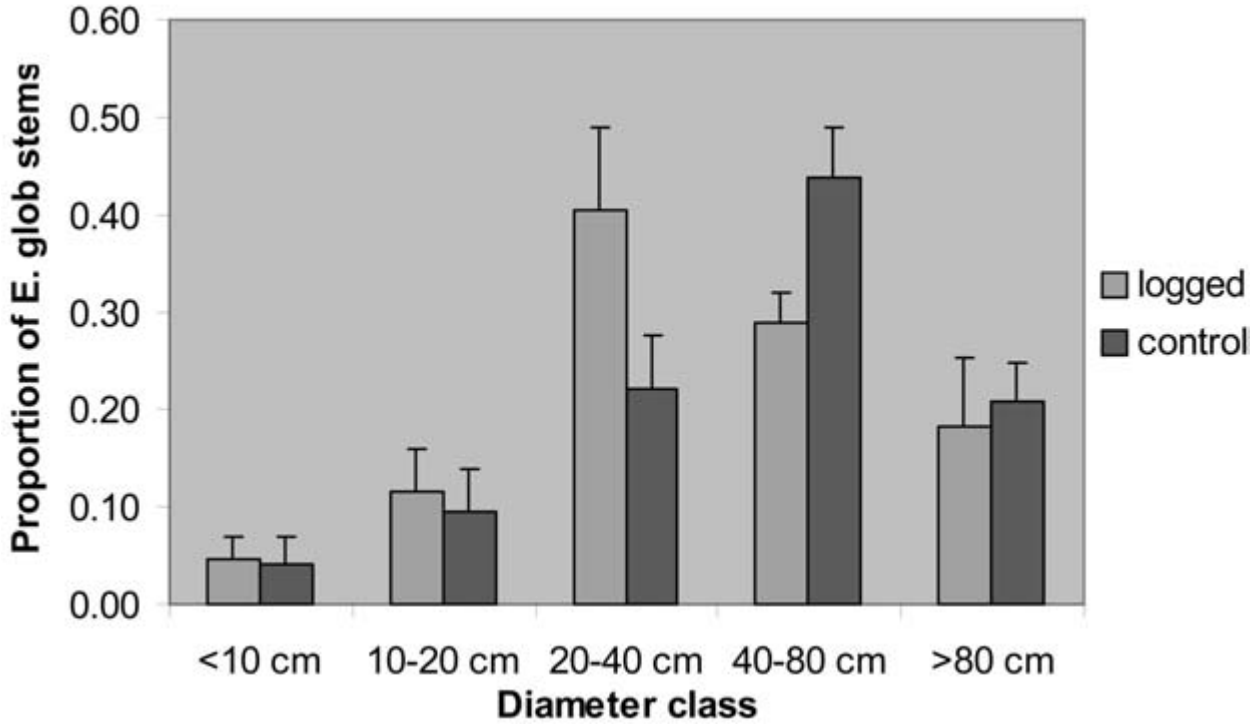

Figure 3. The proportion of Blue Gum *E. globulus* stems of different diameter class in clumps retained in operation areas and in 'control' clumps (mean ± se).

The diameter-class distribution of Blue Gum trees retained in the operation areas, and those retained in the 'control' areas, were similar (Figure 3). However, a greater proportion of Blue Gum trees in the 20-40 cm class, were present in the clumps retained in logged areas compared to the proportion in 'control' clumps. Further, more 40-60 cm diameter trees occurred in the 'control' clumps than in the clumps in logged areas (Figure 3).

Disturbance levels within clumps of trees retained in logged areas were found to be high. Only 1 of the 31 habitat clumps surveyed was undisturbed. Forty-five percent of retained habitat clumps showed very high levels of disturbance, characterised by signs of frequent stock access, grazing by cattle and sheep, firewood collection and the presence of human litter. These clumps were generally small in size and many were on rocky knolls.

Discussion

Although the CAR reserve objectives pursued through the State's Private Forest Reserve Program will go some way to creating a network of protected food resource for the Swift Parrot on private land, there is still a need to conserve foraging habitat in the intervening patches which do not meet this program's reservation criteria (Brereton 1997). A large proportion of these intervening patches are being converted in land use. For example, 25 % (1,000 ha) of the forest, covered by the timber harvesting plans assessed in this study, was converted to pasture or plantation. To ensure that foraging habitat for the species is conserved in these 'off-reserve' areas, the implementation and monitoring of conservation measures are essential.

This study has shown that management prescriptions, advised by specialists, to conserve Swift Parrot foraging habitat were incorporated in timber harvesting plans. However, the results also show that the level of detail provided in the plans needs be improved to assist those foresters implementing management prescriptions during harvesting operations. In particular, the timber harvesting plan map needs to illustrate the location of potential foraging habitat and areas to be retained. Often the specialist's advice was incorporated into the plan verbatim without any attempt to interpret it for the contractors. This was considered to be a significant weakness in the planning process since often those who develop and write the timber harvesting plans are not directly involved in their implementation during the operation.

Although clumps of trees were retained in all harvest areas, in general the number of Swift Parrot forage trees captured in each clump was fewer than required. Comparison of the percentage and size of Blue Gums retained in clumps in harvest areas and control areas suggested that those marking out the prescribed clumps did not consistently target mature Blue Gum as required. In most situations, the data also allow the conclusion to be drawn that forage trees were sparsely distributed in the operation areas prior to harvest, and that the clump prescription was inadequate to capture them at the prescribed rate. The vegetation in 7 of the 10 operation areas was classified, during pre-logging surveys, as high quality foraging habitat by foresters and specialists. However, only the State forest operation (number 17, Table 1) had retained vegetation that was found to be similar in structure and composition to areas classified by Brereton (1997) as high quality foraging habitat based on observations of Swift Parrot foraging behavior. The results identify that, prior to logging, all the other operation areas, and adjacent areas of intact forest, on private land, had sparsely distributed patches of forage trees and signs of previous disturbance. The implementation of the prescriptions for the retention of clumps of trees in the State forest operation area did result in the required retention of Swift Parrot forage trees. However, the results, in general, enabled us to conclude that, in areas with a high occurrence of suitable forage trees, it would have been more appropriate to completely retain them as a large patch, in most of the operation areas.

Following a preliminary analysis of the information reported in this paper, and further research on the requirements of the species by Brereton (1997), the prescriptions for the conservation of Swift Parrot foraging habitat were updated in 1997 (Forest Practices Board 1998) and then again in 2001 (Forest Practices Board, 2001a). The revised prescriptions aim to retain all patches of the forest communities known to constitute prime foraging habitat for the Swift Parrot, i.e. all grassy *E. globulus* forest and shrubby Swamp Gum *E. ovata* forest (Brereton 1997). This change complements the increased regional reservation of the Swift Parrot forage resource undertaken since 1996 by the Tasmanian Public Land RFA process and the Private Forest Reserves Program. Seeking specialist advice to assist with clarification of the quality of habitat and identification of patches to be retained, before commencement of any forestry operations, is now mandatory.

In addition to the upgrading of the Swift Parrot prescriptions, several other steps have been taken to improve the implementation of threatened fauna conservation measures, in areas subject to forestry operations. The level of understanding by those involved in implementing threatened fauna conservation measures has been raised through an intensive training program (Forest Practices Board 1997; Munks and Taylor 2000). In addition, planning tools (Forest Practices Board 2001a, b) have been refined to ensure forest officers have access to the most up-to-date information about a particular species as well as a prescribed action. A greater level of detail in timber harvesting plans (now known as Forest Practices Plans), and associated background information, is now also required, to ensure that the decision-making process is transparent for future monitoring, and, to ensure that the on-ground actions required are clear for contractors.

The observation of post-harvest disturbance reported in this study highlighted the urgent need for mechanisms to assist the long-term viability of any conservation measures on private land. At the time of this study, under the Tasmanian Forest Practices System, harvesting plan prescriptions on private land, including those for threatened species, were only valid for the life of the plan (generally 2-3 years) unless the land was a designated Private Timber Reserve (Forest Practices Board 2000b). In 2001, changes to the *Forest Practices Act, 1985* provided that areas 'reserved' under Forest Practices Plans become vulnerable land, even after the Forest Practices Plan (formerly called Timber Harvesting Plan) expires. No further clearing or harvesting is permitted on such vulnerable land retained for threatened species, such as the Swift Parrot (G.Wilkinson, pers. comm). Achieving a balance between a landowners land use requirements, and the protection of retained areas, will be an ongoing challenge, and further incentives, rewards and education programs need to be developed before the long-term viability of off-reserve mechanisms for the conservation of threatened species can be assured.

This study illustrates the view that acquisition of detailed information on the implementation of 'off-reserve' conservation measures is vital to ensure that management prescriptions are achieving conservation outcomes for the species. Adopting such an adaptive management approach (Lindenmayer and Recher 1998; Hobbs and Saunders 2000) is essential when our knowledge base of species' habitat and/or conservation requirements is incomplete, and that potentially threatening land use practices are continuing. Anecdotal information shows that the upgrading of the Swift Parrot conservation measures, increased education, improved planning tools and increased legislative protection for retained areas have gone some way to achieve improved conservation outcomes for the Swift Parrot on private land. Ongoing monitoring of the implementation of the revised prescriptions is required to ensure standards are maintained. In addition, there needs to be regular monitoring of the effectiveness of the prescriptions in sustaining local populations of the Swift Parrot. With adequate resources, the adoption of a "closed loop" between research, monitoring and upgraded management (Lindenmayer and Recher 1998), as illustrated by this study, can assist the achievement of 'off-reserve' conservation goals in Tasmania's production forests.

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APPENDIX I

Adult Swift Parrot.

Photo: D. Watts.

Grassy Tasmania blue gum *Eucalyptus globulus* forest in south-eastern Tasmania.

Photo: D. James.