

Cupper 1981; Pruett-Jones *et al.* 1981) although there are no such records in Tasmania (Mooney and Brothers 1987). A deserted *A. a. fleayi* nest in north-western Tasmania was taken over by a pair of white-bellied sea eagles (*Haliaeetus leucogaster*), a species apparently more tolerant of disturbance and flexible in choice of nest sites. However, this nest tree later fell, probably as a wind-throw because of exposure during logging. The bases of some of these oldgrowth trees are at least partly burnt out and many that were sheltered do not survive exposure to high winds.

Breeding success dropped off markedly on land without a high security of reservation. However, if we categorise State forest with tenures of poor security of reservation, 62.5 per cent of territories on land with medium security were successful, about the average for the whole State. Only territories on land with poor security performed especially badly. Unfortunately, that includes 69 per cent of the State's eagle territories if we include State forest.

At the moment, 'hands on' population enhancement techniques are not necessary for the conservation of *A. a. fleayi*. However, they are available and have been used

successfully for other large eagles of the genus, the Spanish imperial eagle (*A. adalberti*) (Meyburg 1987; Gonzales *et al.* 1986), and the golden eagle (*A. chrysoetias*) (Postovit and Postovit 1985).

We are especially concerned at the poor breeding performance in State forest. This seemed largely a result of earlier ignorance, occasional lack of full compliance with the Forest Practices Code, a sometimes cavalier attitude by private forest companies in concession areas and on private land, and the almost universal lack of pre-logging fauna surveys. Despite recent improvements in procedures and attitudes, past problems will have serious effects for many years. Unfortunately, many of the mistakes are being repeated on private land. Protection levels for nests on private land ranged from deliberate destruction to those jealously (and very well) guarded, virtually as heirlooms.

Although comparatively few eagle nests were in streamside reserves, many more could be conserved by modification of these areas by adding a Wildlife Priority Area and/or Wildlife Habitat Strip (Taylor 1990; Fig. 3).

There is no special need for nest sites to be kept confidential as long as the

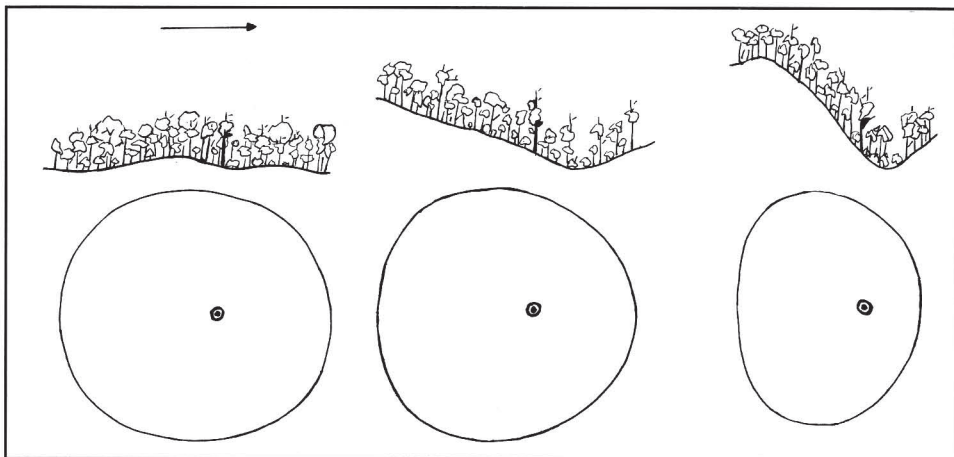


Figure 2. Side and plan views of recommended shapes and positioning of protective forest around eagle nests in relation to slope. The arrow shows direction of prevailing winds during early breeding (August - November inclusive).

recommendations on disturbance (or the lack of it) can be followed. We believe some exposure to the public, be it actual, pictorial or literary, is necessary for successful public relations and conservation of the eagles.

In many forestry regeneration areas, active control of game is undertaken. Although eagles have been killed by lead poisoning in Tasmania (for example, after eating a shot wallaby), this is not a major mortality factor (N. Mooney, unpublished data). Eagles seem particularly susceptible to persecution (Mooney and Hunt 1983) and even locally high levels can affect populations (Brown 1991). Despite legal protection and efforts at educating the public (for example, Anon. 1988), persecution of *A. a. fleayi* is still locally intense and there remains a high level of mortality from shooting and deliberate poisoning in Tasmania (approximately 8% per year of adults, 60% of immatures, cf. theoretical natural totals of 5-10% and 90-95%; N. Mooney, unpublished data; Newton 1979) and it is important that this is alleviated. Improved education is obviously necessary. When allowing shooters access, landowners/managers must make it clear

that wildlife the hunters are not licensed to take must be left unharmed. Stock owners should be more responsible with their use of poisons, some of which are regularly used in illegal attempts to kill wildlife. Offences should be reported to the Department of Parks, Wildlife and Heritage (DPWH).

Control of game by sodium monofluoroacetate (1080) poisoning is a contentious issue but despite anecdotal claims, there is no evidence of eagle mortality resulting from poison programmes that are carried out according to legal guidelines. Fortunately, *A. a. fleayi* appears to prefer live-caught prey when provisioning young, somewhat reducing the chances of secondary poisoning. The physiological tolerance of eagles to 1080 is relatively high (McIlroy 1984). However, circumstances may arise where exceptions occur and any suspect carcasses should immediately be forwarded to DPWH or the Department of Primary Industry for post-mortem examination.

The stability of breeding success between years and the dispersed nature of our sampling we believe justified our reliance on

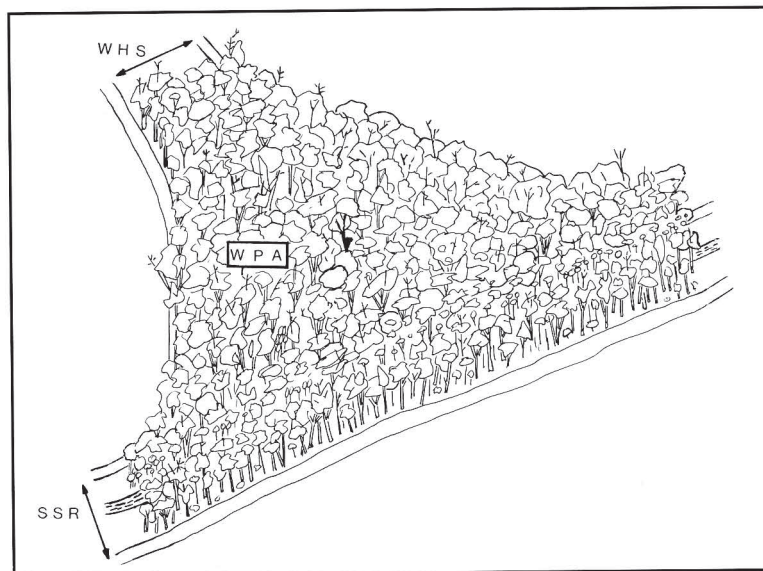


Figure 3. Inclusion of Wildlife Priority Area (WPA) based on an eagle nest at the junction of a wildlife habitat strip (WHS) and streamside reserve (SSR). Protection from regeneration burns is afforded by roads and fire breaks.

the 1989 results. We believe the low breeding success was not due to pollution. Levels of organochlorine pesticides in tissues of *A. a. fleayi* are low and have not been implicated in breeding failures or deaths (N. Mooney, unpublished data).

If the data from little-disturbed pairs (85% successful) is applied to Tasmania's 138 territories, 117 should be successful. The actual 75 that are so is a 36 per cent decrease, which is serious because of the small absolute numbers.

With continued land development, there could arise a situation where most, if not all, heavily disturbed nests become unproductive, moderately disturbed nests become heavily disturbed, those lightly disturbed become moderately disturbed and those under no disturbance become lightly disturbed. Using data on productivity under different disturbance regimes (Table 2), we can then calculate that numbers of productive pairs could drop from the current 75 to about 43 pairs, a 65 per cent decrease and dangerously low considering other problems may arise. A 'worst-case' scenario with increased human population could involve increased persecution and accidental deaths (from collision with vehicles, wires, electrocution, lead poisoning etc.), pollution, exotic pathogens and/or decrease in the food base and result in an even lower population. A deliberate effort by government departments and the public is required to prevent this. We believe a combination of voluntarily sensitised land use and firmer implementation of current developmental guidelines (for example, Forest Practices Code) may be all that is needed.

For genetic purposes, population size is defined in terms of effective size which has a major effect on both rate of inbreeding and maintenance of genetic variation. Effective population size is the number of individuals that contribute approximately equally to the next generation, importantly a figure often much less than the census. Estimates for

minimum effective populations vary, from 50 to avoid inbreeding to 500 to avoid loss of genetic variation (Falconer 1960; Franklin 1980). Obviously, long-term conservation and the successful fulfilment of ecological niches require higher populations than minimums to prevent inbreeding. Although we did not have sufficient detailed data to calculate an accurate effective population size for *A. a. fleayi*, in reality it can only be lower than the number of breeding adults, that is, 150, a number arguably sufficient to prevent inbreeding but which may result in the loss of genetic variation.

Although population modelling of the bald eagle (*Haliaeetus leucocephalus*) suggests small populations of large eagles are more sensitive to decreases in survival than reproductive rates (Grier 1980), we believe such a low prospective effective population needs active maintenance, if not heightening, of the above vectors. In a resident population not under undue stress, replacement of adults should occur within months if not weeks (Newton 1979). The fact that this did not always happen with *A. a. fleayi* is further evidence that the population is under unusual stress. Although we found no evidence of inbreeding (fertility and immunity seem normal), it is important that some DNA examination of the population is undertaken and genetic diversity compared with the much larger mainland Australian population.

The development of rural land for residential purposes, with its attendant high levels of disturbance, is very harmful to sensitive wildlife such as nesting eagles. Housing scattered through rural areas often leaves too little undisturbed land. South Arm, south-east of Hobart, is a typical example. We believe the conservation of nests in disturbed areas is particularly important for the future (Mooney 1988c). Eagles using them are tolerant of a certain degree of disturbance and presumably they produce tolerant young (by hereditary and/or habitative means). To be effective, this process relies heavily on decreased vandalism/increased tolerance by people.

(a)



(b)

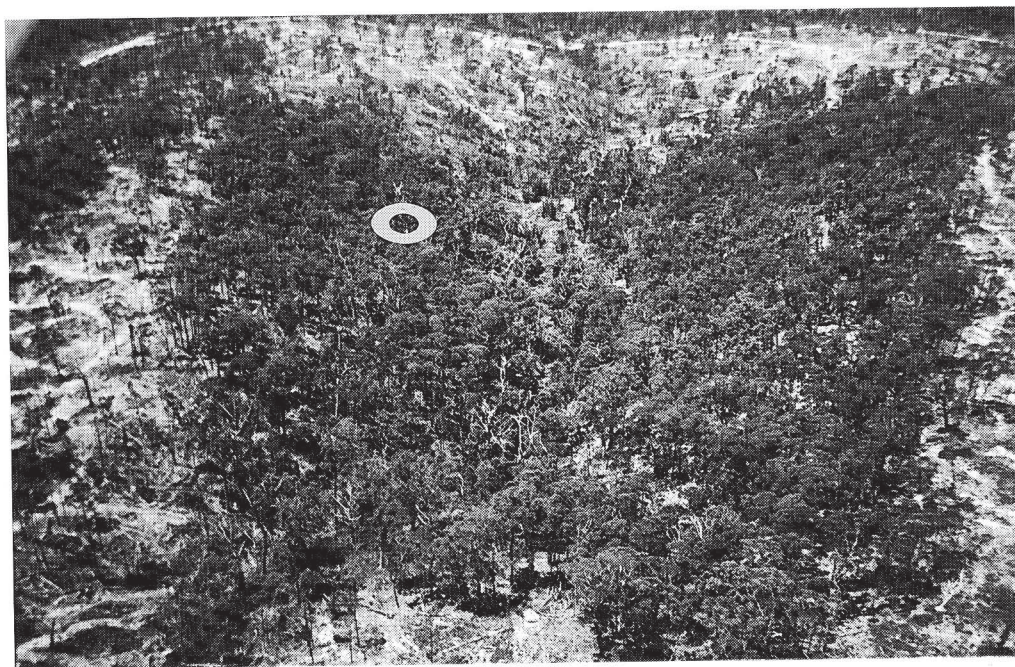


Photo 2. Protection of eagle nests - extremes. Above (a) - complete isolation of a nest tree. This nest has been deserted for the three years since logging. Below (b) - approximately 15 ha left around a nest found during logging. Although deserted in the year of disturbance, breeding occurred the following year. (This nest was reported and the reserve created by Richard Hart, Forest Resources.)

So far, conservation of nest sites has had varied success. When there has been a chance to carry out recommendations, success has been high. However, there exists residual fear amongst some private landowners that if they report nests they may lose control of at least part of their land. This fear may arise from a general suspicion of government. Such nest sites may be in special danger if authoritarian efforts are made to introduce legislation intended to be protective (this happened in the Victorian Mallee Region as a result of farmers fearing legislation similar to the Nature Vegetation Management Act 1985 of South Australia). The deliberate felling of a contentious nest tree in State forest at Ellendale in 1991 illustrates the fine line that successful conservation must tread. Protective measures must be implemented openly. We intend our recommendations to contain a degree of flexibility to allow change from the ideal, if necessary.

Co-operation from the Forestry Commission and private landowners has generally been very good although some forestry officers do not always report nests. The record of private forestry companies has been chequered with notable enthusiastic efforts, abject failures (for example, Photo 2) and occasional apathy. Importantly, attitudes of some companies have greatly improved and we hope this continues. In fact, it is vital for the long-term welfare of *A. a. fleayi*. The reality is that many nests are found during actual land 'development'. This may be very difficult to avoid since nests can be surprisingly hard to find and, under current procedures, pre-logging surveys are rarely undertaken. Only in well-searched areas can it be assumed all nests are known and of course the situation is somewhat dynamic, some nests disintegrate naturally while others are constructed. Land managers are therefore often faced with rescue situations but it is still worth following conservation advice as much as possible. Success will invariably rely heavily on a mix of enthusiasm and imagination, with a touch of generosity.

Recommendations

Because of the variety of scenarios in which eagle nests are discovered/disturbed, general advice that can be adapted by reference to the preceding text will be given.

1. Human activities that are highly disturbing should be positioned as far from the nest as possible, preferably out of sight or below, and must be timed away from the breeding season (August-January inclusive) especially the early stages.
2. An area of 10 ha of primarily oldgrowth eucalypt forest should be regarded as a minimum reliable copse size for breeding. Additional area to 20 ha is preferable. This protective forest should surround the nest and be concentrated uphill and/or to windward (of winds prevailing in the above period). Protection from severe fires (e.g. regeneration burns) should be maintained.
3. Human disturbance should be minimal in the core 10 ha and logging in the surrounding 10 ha restricted to thinning, to a maximum of 50 per cent by numbers, while retaining canopy height.
4. Where all known nests in a territory have been destroyed and there are less than three suitably placed alternate areas of remnant forest within 2 km of the *loci* of the original nests, three suitably sized and placed areas of regrowth should be set aside for nesting habitat. When remnant habitat is less than 20 ha, areas of adjacent regrowth to make up the difference should be assigned that role.
5. All nests should be treated the same and conservation measures should be permanent.
6. Productivity of 'rescued' nests should be monitored.

7. Control of game by the use of toxic chemicals in principal foraging areas of eagles should be conservative.
8. Efforts to reduce persecution should be made and offences reported to the Department of Parks, Wildlife and Heritage.
9. The Forest Practices Code must be fully complied with. Although, as a rare species, there are no specific requirements for conservation of *A. a. fleayi* under the Code, other aspects such as proper control of regeneration fires can have important repercussions for eagles. The flexibility of the Forestry Commission's reserve system certainly can cater for breeding eagles.
10. An Agricultural Practices Code should be developed, preferably for voluntary use.
11. All nests found during any stage of a logging operation and any change in conservation status of known nests should be reported promptly to the Department of Parks, Wildlife and Heritage or the Forestry Commission (Forest Practices Unit). Consultation with land managers in those agencies is encouraged.
12. Serious attempts should be made to find nests, preferably before land development commences and certainly before nests are seriously disturbed. Searching should occur at least 1 km ahead of logging.
13. Locations/descriptions/histories of nests should be recorded in a Geographic Information System, providing that wishes of confidentiality and security of information by landowners/managers is respected. However, the list of nests should not be regarded as definitive.
14. DNA examination of *A. a. fleayi* should be undertaken to define the degree of inbreeding.

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