Forest management and species conservation

An important debate in conservation concerns whether sustainable harvesting is acceptable as a means of conserving biodiversity or whether the main thrust should be towards increasing the number of totally protected areas. In no area is the debate more apparent than in the protection of forests world-wide and the use of sustainable forest management (SFM). Those in favour of SFM say that it is economically viable with lower operating costs and higher profits than conventional methods (Gascon *et al.*, 1998), that protected areas cannot stand alone surrounded by a sea of degraded landscape and that SFM is the best way of ensuring buffer zones around such reserves (Cabarle, 1998), and that commercial logging is unlikely to stop, and with only 8 per cent of the world's forests under protection it is unlikely that a policy of protection can avoid massive species extinctions. Other evidence suggests that SFM is not economically viable and is therefore unlikely to be adopted by many commercial enterprises, that it may actually encourage companies to log continuously in remote forests, and that after nearly two decades of effort only a tiny percentage of tropical forests is managed sustainably (Bowles *et al.*, 1998).

Recent research is equivocal on the subject. Cannon *et al.* (1998) show that despite severe structural damage, 'unsustainably' logged areas of tropical rain forest in Indonesian Borneo can retain high tree species richness. Eight years after logging, tree density was lower than in unlogged stands but if the same number of trees were counted in both types of forest (in logged forest over an area 1.5 times that of unlogged forest), then species richness was similar. Furthermore, rare species that survive damage could benefit from removal of the dominant tree competitors (Cannon *et al.*, 1998). However, the authors point out that the study does not look at the effects of logging on landscape-scale fragmentation, nor is the time scale of the study sufficient to assess the species-specific dynamics of tree regeneration over decades.

Research on forests where sustainable management is practised is encouraging. Examination of tree community diversity of lowland swamp forests in north-east Costa Rica, where *Pentaclethra macroloba* and *Carapa nicaraguensis* are extracted using a system designed to minimize damage to the residual stand and to promote natural regeneration (Webb & Peralta, 1998), showed that tree community diversity was not greatly affected by selective logging. However, even low-impact logging can eradicate rare species locally and because this was a short-term study, research looking at the long-term effects of low-impact logging on the population dynamics of rare species is required.

Research on commercially unimportant species is less encouraging. The avifauna of Kibale National Park, Uganda, had not fully recovered 23 years after logging occurred. A comparison of logged and unlogged forest compartments showed that species diversity and richness were higher in the logged area, but the majority of birds were generalist or forest-edge species, and while 84 per cent of the interior-specialist species had recolonized or persisted in the logged area, seven of the 48 understorey specialists had not done so (Dranzoa, 1998).

Research examining the effects of different logging disturbance levels on southern flying squirrels *Glaucomys volans* in Arkansas found that behavioural and demographic responses of the species depended on the harvesting practices implemented. Researchers used an array of 12 cutting treatments, ranging from pine–hardwood single tree selection to clearcutting, plus an uncut control, replicated in four forest zones. Initially squirrels were forced to emigrate from the forest at all levels of harvest activity but were able to persist in forest fragments by using mature forest areas, green-belt habitat within harvested areas and by avoiding logged habitats (Taulman *et al.*, 1998). However, squirrels were not able to tolerate disturbance at or above a certain harvest level and the effects of predation appeared to be worse in disturbed habitats. Finally, local squirrel populations were unable to survive the harvesting of stands surrounded by unsuitable habitat, such as pasture or young pine plantation. This suggests that logged stands will not be recolonized unless surrounded by source forest or connecting corridors of forest (Taulman *et al.*, 1998).

The fact that sustainable forest management may not be appropriate for some species is indicated in a study by Sedgeley & O'Donnell (1999), who looked at roost selection by the long-tailed bat *Chalinolobus tuberculatus* in temperate rain forest in New Zealand. Bats selected roosts on the basis of topography, forest composition and tree characteristics. Trees selected tended to be taller, older (74 per cent of roost trees were 100–600 years of age), with larger trunks and more cavities than random trees, the very trees that are targeted for removal under most forest management practices (Sedgeley & O'Donnell, 1999). The behaviour of this species may mean that outside protected areas populations may be limited by availability of suitable roost trees.

Other research using field experiments to examine the effects of clearcutting on amphibian populations in the south-eastern US has found that, contrary to results obtained in comparative studies, habitat modification resulting from such practices does not have detrimental effects on newly metamorphosed mole salamanders *Ambystoma talpoideum* (Chazal & Niewiarowski, 1998). Recently metamorphosed salamanders were randomly assigned to four 100-sq-m field enclosures built in each of two habitats, a 4-month-old clearcut and an adjacent 40-year-old pine forest, and data on growth rate, fecundity, age at maturity and whole-body storage lipids were collected. Although there were no differences in any of the measures between the two habitats, salamanders in these experiments, unlike those in comparative studies, were not exposed to the mechanical disturbances of clearcutting. Therefore, it may be that reduced species abundance and diversity in clearcuts relative to undisturbed sites arises from direct mortality during tree removal and subsequent site preparation, although there are currently no data to test this hypothesis.

In managed conifer forests, habitat alteration, involving the removal of deciduous vegetation to facilitate growth of conifer seedlings, often continues after logging has occurred. Easton & Martin (1998) looked at the effect of removing 90–96 per cent of the volume of deciduous trees on breeding bird communities in young conifer plantations in British Columbia during a 4-year study. Control plots were compared with plots where trees were removed manually or using a herbicide. Plots treated with herbicide had the highest turnover of species and showed a decline in the number of species, with common species dominating. Nesting success of open-cup nesting species was lower than in manually thinned areas and there was a decline in deciduous specialists such as warbling vireos *Vireo gilvus*. But residents, short-distance migrants, ground gleaners and conifer nesters increased in areas with this treatment. Manual thinning produced different results with an increase in deciduous nesters and foliage gleaners. These results suggest that different management regimes may be a mechanism for producing greater diversity of bird community composition (Easton & Martin, 1998).

Many questions on areas of vulnerability mentioned above cannot be answered because the research has not been carried out (Chazdon, 1998), and more research is urgently required on the long-term effects of SFM on species that are not considered commercially important.

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Introduced species

Many species introductions into new geographic areas are well known for their devastating effects upon native fauna and flora. In terms of conservation management it is important to understand the effects that invaders have on native species, to identify the attributes of successful invaders and the mechanisms of their success.

The Argentine ant *Linepithema humile* is a widespread invasive species that competitively displaces native ants throughout its introduced range. Holway (1998) compared the competitive abilities of the Argentine ant with seven native species that it displaces in riparian woodlands in northern California. He looked at both exploitative competition, where one species is more successful than another at locating and obtaining food, and interference competition, where one species aggressively displaces another. For the native ants in this study there was a negative correlation between exploitative and interference abilities but this was not the case for

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Argentine ants, which both located baits more quickly than native ants and were more aggressive, particularly at the colony level, with most Argentine ant colonies displacing native ant colonies from baits. The fact that there appears to be no competitive trade-off for Argentine ants may explain the patterns of invasive success (Holway, 1998).

Population modelling has been used to assess the reasons for the higher population densities of the introduced toad *Bufo marinus* in Australia than in its native South America. The model predicted equilibrium population densities in Australia one order of magnitude higher than in South America and higher adult survival appeared to be the main reason, giving a possible insight into methods for controlling this species in Australia (Lampo & De Leo, 1998).

A comparison of the photosynthetic abilities of invasive and native Hawaiian rain-forest species showed that overall, invasive species appeared to be better suited than native species to capturing and utilizing light resources, particularly in high-light environments such as those characterized by relatively high levels of disturbance (Pattison *et al.*, 1998).

Several studies have examined the effects of introduced species on native species and ecosystems. Gordon (1998) has looked at the ability of non-indigenous plant species in Florida to modify ecosystem properties. In a review of studies on 31 species, she found that the majority of species altered native ecosystems in a wide range of ways. The majority also showed superior competitive ability, with traits capable of modifying natural systems at both ecosystem and population scales.

More specifically, the muskrat *Ondatra zibethicus* appears to be responsible for the decline in diversity in aquatic plant communities on Vandaam Island, Northern Russia. The island was invaded by the muskrat in the 1970s, and comparisons of the same aquatic plant communities in 1962 and 1993 showed a substantial decline in various diversity measures and an increase in the plant species resistant to grazing by this species (Smirnov & Tretyakov, 1998). The muskrat was deliberately introduced into Eurasia in the 19th century for commercial reasons and very little research has been done on its impact on native flora and fauna.

Another deliberate introduction may be affecting populations of North American grassland songbirds. Sutter & Brigham (1998) compared the composition of plant species, habitat structure and bird species diversity in native mixed grass prairie and introduced vegetation dominated by crested wheat grass *Agropyron pectiniforme*. They found that introduced vegetation provided less cover for the nesting birds and that the abundance of some bird species such as Baird's sparrow *Ammodramus bairdii* and Savannah sparrows *Passerculus sandwichensis* increased in the more sheltered habitat of the native vegetation.

Rare species may need particular protection from introduced species, as shown in research on the effects of introduced plants on the rare plant *Solidago shortii*. A comparison of the growth and survival of *Solidago shortii* in plots free from other vegetation with plots where the species was grown with the introduced species *Coronilla varia* and *Festuca arundinacea*, showed that growth of plants was most vigorous and seedlings only established in plots where the introduced competitors were absent (Walck *et al.*, 1999).

Finally, having examined research on aspects of conservation management and introduced species it is worth mentioning the cost of active management. Wilcove & Chen (1998) interviewed 160 scientists and land managers to obtain an estimate of the cost of actively managing habitats to maintain their long-term suitability for endangered species. They included only the cost of combating alien species and maintaining natural fire regimes. They concluded that it would cost $32–42 million to protect endangered species in the US from just those two threats. This is the cost of the toilet on the space shuttle, but is a substantial amount of money in conservation circles (Wilcove & Chen, 1998). The research shows that even with the best will in the world, insufficient funding may result in many endangered species being doomed to extinction.

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