COMMENTARY

Conserving biodiversity in a world of conflicts

Historically, humans have chosen to settle in areas that were also favoured by large numbers of other species. Fjeldså & Rahbek (1998) were the first to report a strong continent-wide correlation between human population pressure and priority areas for South American birds. They also showed that centres of development of earlier civilizations in the tropical Andes were immediately adjacent to local peak concentrations of avian endemism. Subsequent studies have similarly reported correlations between human population density and the species richness of a variety of taxa and regions (Table 1).

Authors have speculated that the correlation between people and biodiversity may arise because humans and other living organisms depend on processes that are driven or perhaps delimited by contemporary available energy (e.g. Balmford *et al.*, 2001; Evans & Gaston, 2005; Luck, 2007). An alternative view proposes that areas characterized by climatic stability over historical time have: (1) ensured human development through the provision of stable and predictable ecosystem services, and (2) facilitated the survival of relicts and the diversification of new taxa (Fjeldså & Rahbek, 1998).

In a recent paper in the *Journal of Biogeography*, Luck (2007) found that human population density and species richness among Australian birds, butterflies and mammals responded similarly to variations in net primary productivity (NPP), leading to spatial congruence between human settlements and productive, species-rich regions. It was also found that small parks were often surrounded by relatively dense settlements in regions with high average NPP, while large parks were mostly isolated and characterized by low productivity. Luck concluded that planning strategies are needed in order to minimize the level of human pressure on biodiversity. To achieve this goal the author proposes the stabilization of human population and the conservation of large areas of relatively high productivity within conservation areas. These conclusions are supported by the measured congruence between species richness, human population density and productivity. Luck acknowledges, however, that, when it comes to selecting areas of priority with regard to biodiversity conservation, species richness is a poor measure of conservation value.

Conservation value can be measured in multiple ways, and, depending on the value system adopted, the results are likely to be different. In conservation planning, value is often assessed as the relative contribution of

Table 1. Examples of results from a sample of studies exploring the correlation between human population density and species richness

Region	Data resolution	Taxa	Correlation	Study
Africa	1°	Plants	$r_s = 0.56$	Balmford *et al.* (2001)
		Birds	$r_s = 0.59$	
		Mammals	$r_s = 0.43$	
		Snakes	$r_s = 0.43$	
		Amphibians	$r_s = 0.35$	
Australia	1°	Birds	$r_s \geq 0.6$	Luck *et al.* (2004)
		Mammals	$r_s \geq 0.4$	
		Amphibians	$r_s \geq 0.5$	
		Reptiles	$r_s \geq -0.2$	
		Butterflies	$r_s \geq 0.7$	
Europe	50 × 50 km	Plants	$r_s = 0.51$	Araújo (2003)
		Birds	$r_s = 0.19$	
		Mammals	$r_s = 0.47$	
		Herptiles	$r_s = 0.56$	
North America	Ecoregions of varying sizes	Birds	$r_s \geq 0.6$	Luck *et al.* (2004)
		Mammals	$r_s \geq 0.4$	
		Amphibians	$r_s \geq 0.8$	
		Reptiles	$r_s \geq 0.8$	
		Butterflies	$r_s \geq 0.6$	
Brazil (Cerrado)	1°	Anuran	$r = 0.46$	Diniz-Filho *et al.* (2006)
Tropical Andes	0.25°	Birds at risk	$r_s = 0.18$	O'Dea *et al.* (2006)
Chile	0.5°	Marine vertebrates	$r_s = 0.51$	Tognelli *et al.* (2005)
Global	Nations of varying sizes	Threatened mammals and birds	$r = 0.63$	McKee *et al.* (2003)

areas to achieving a conservation goal. Typically, the goal is to represent as many species as possible (or to maximize their probability of persistence) within sets of conservation areas, and this is best achieved using complementarity (a property of areas that exists when at least some of the species in one area differ from the species in another area). Previous studies have shown that the selection of conservation areas based on species-richness scores alone can lead to a poor representation of species in conservation areas. For example, a study showed that, if a given number of 'hotspots' of richness were selected to conserve British breeding birds, 89% of the species in Britain would be represented; alternatively if the same number of areas were selected using complementarity, all species would be represented at least six times over (e.g. Williams et al., 1996). Thus, planning strategies for biodiversity conservation should endeavour to minimize the level of pressure within sets of complementarity areas, rather than focusing on species-rich areas, as acknowledged by Luck.

But do complementarity areas coincide with high human population density? This issue is not addressed by Luck (2006), but, because complementarity is affected by both richness and rarity, there is a possibility that areas of high complementarity may occasionally coincide with areas of high human population density. This was indeed the case for complementarity areas identified in sub-Saharan Africa (Balmford et al., 2001), Europe (Araújo et al., 2002), Australia and North America (Luck et al., 2004), South America (Fjeldså & Rahbek, 1998), and the Tropical Andes (O'Dea et al., 2006), but not the case of complementarity areas selected for anuran species in the Cerrado region of Brazil (Diniz-Filho et al., 2006).

Evidence in support of a widespread coincidence between complementarity and human population density is still incomplete, and the mechanism that would explain such a coincidence remains elusive. Unlike species-richness patterns, which have been studied in great detail for at least the past 100 years, the determinants of complementarity have barely been discussed in the literature. Therefore, rather than focusing on the theory, a more pragmatic solution for solving potential coincidences between complementarity and human pressure is to incorporate conflict minimization within reserve selection. For example, Araújo et al. (2002) and Luck et al. (2004) showed that complementary areas within western Europe, Australia, and North America could contain significantly fewer people if a 'people avoidance' rule was incorporated in the reserve selection algorithm.

In regions such as Europe and Australia, biodiversity conservation may be facilitated through the careful selection of networks of conservation areas that minimize the conflict while maintaining overall representation of species (Araújo et al., 2002; Luck et al., 2004). However, in regions with a high spatial turnover of species, where complementarity is strongly driven by the presence of non-nested irreplaceable sites (i.e. sites that are mandatory for achieving conservation goals), there is limited flexibility to adopt conflict-minimization strategies. It follows that, if irreplaceable sites coincide with areas of high human impact, as reported, for example, for sub-Saharan Africa (Balmford et al., 2001) and for the tropical areas of Australia (Luck, 2007), there is no easy and pragmatic solution for avoiding conflict. Unfortunately, limited flexibility for conflict minimization is likely to be a common pattern in the Tropics, where >90% of all species live. Therefore, the challenge in some of the most species-rich regions of the planet might not be to adopt the conflict minimization strategy that was shown to be possible in Western Europe, Australia, and North America, but to learn from examples in which conservation of species and human development have succeeded hand-in-hand.

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