BIODIVERSITY

Species loss revisited

Conservationists predict massive extinctions as a result of habitat loss. Habitat loss undoubtedly does drive extinctions, but dealing with an unmet assumption that underlies these predictions yields much lower estimates. SEE LETTER P.368

CARSTEN RAHBEK & ROBERT K. COLWELL

Scientists generally agree that Earth is facing a biodiversity crisis, losing species 100 to 1,000 times faster than the normal background rate of extinction[1] and resulting in the sixth period of mass extinction in Earth's history. On page 368 of this issue, He and Hubbell[2] provide a fresh perspective on predictions of the rate of this species loss.

Previous periods of mass extinction were driven by global changes in climate and in atmospheric chemistry, bolide impacts and volcanism[3]. This time, species extinction is a result of interaction and competition for resources with another species — humans. We are immensely successful. Our numbers are many times higher than ecological theory would predict for a species with our life history and body mass. We explore, populate and drastically alter almost all corners of the Earth and modify the global climate. Loss of habitat is predicted by various studies to cause the extinction of 20–50% of all species in just half a century[3]. These estimates began to surface decades ago, but sceptics have repeatedly demanded evidence of widespread extinction, asking 'Where are the bodies?'. If proof is not forthcoming, they argue, then politicians and decision-makers should denounce the biodiversity crisis as a myth[4].

He and Hubbell[2] question the way that extinction rates attributed to habitat loss have most often been estimated. Biologists have struggled for decades to estimate how many species are going extinct. Traditionally, the answer has relied on estimates based on an almost universal ecological relationship — when we inventory the species in an area of natural habitat, the list grows as the area is increased. Using theoretical or empirically derived functions to describe this species–area relationship (SAR), it has been assumed that, by working backwards along the SAR, one can estimate the number of species that would be lost to extinction if a larger area were reduced by habitat loss.

A classic rule of thumb says that if habitat area is reduced by 90% (comparable to actual habitat loss in many regions), roughly one-half of its species will be lost. He and Hubbell cite studies using SAR that predicted the loss of 50% of all species by the year 2000 — predictions that clearly have not been fulfilled. The discrepancy is well known and has often been explained as 'extinction debt', a time-lag before populations reduced in numbers by habitat loss actually become extinct. Individuals of long-lived species may continue to reproduce or simply live on without reproducing, even if the current living space for the species cannot sustain viable populations over time.

The authors[2] explain why this traditional 'backwards' use of SAR is fundamentally flawed for typical spatial diversity patterns, and show that this approach can produce drastic overestimation of extinction rates.

The problem with the traditional approach is surprisingly simple. With increasing habitat area, the SAR rises by one species unit each time the first individual of a species new to the inventory is encountered (Fig. 1). Additional individuals of a species already encountered add nothing to the species count. By contrast, with decreasing habitat area an extinction does not occur until the last individual of a species is encountered. The authors show that, for the aggregated spatial patterns characteristic of species in real communities, the predicted number of extinctions rises more gradually with increasing habitat loss than predicted by the 'backwards' SAR (Fig. 1). The curve that correctly describes the rate of extinction as habitat

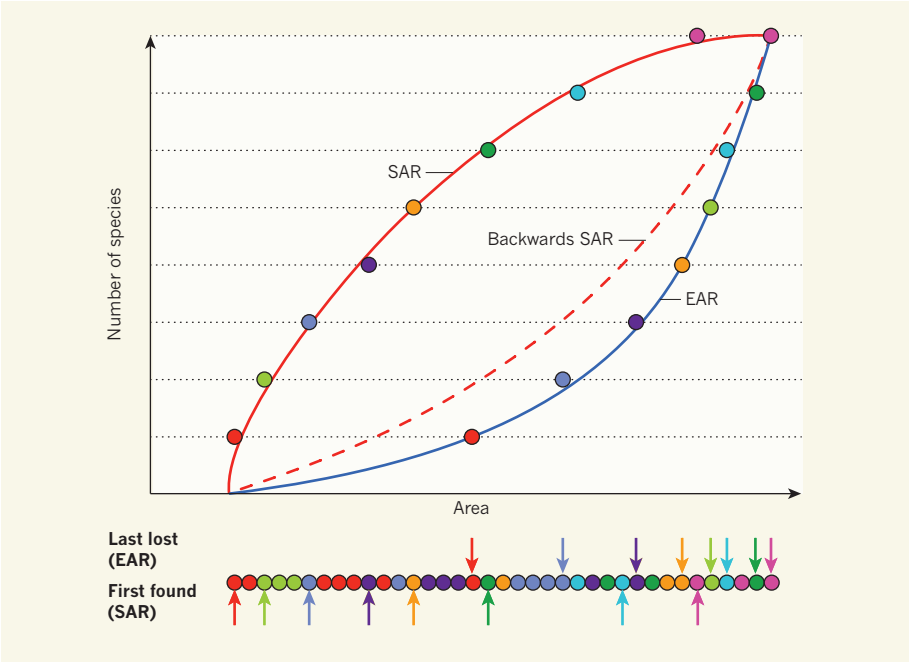

Figure 1 | Estimating species extinctions due to habitat loss. This hypothetical example shows the contrast between use of the backwards species–area relationship (SAR), traditionally used to predict extinctions, and the true endemics–area relationship (EAR) that correctly estimates extinctions with increasing area lost. The coloured circles under the graph represent the spatial ordering of 37 individuals (each occupying one unit of area) of 8 species along a transect through a habitat, each species indicated by a different colour. The total area surveyed increases with each individual encountered. As the first individual of each species is found, the SAR rises by one species, whereas the EAR is incremented only when the last individual of a species is accounted for along the transect. The backwards SAR mirrors the loss of species as area is reduced by moving right-to-left along the SAR. He and Hubbell[2] demonstrate mathematically and with examples for trees and birds that, for realistic (aggregated) spatial patterns of individuals and species, the backwards SAR always lies above the true EAR, thus overestimating expected rates of extinction. Species aggregation is simulated here by placing dots of the same colour closer to one another than expected at random.

area decreases is called the endemics–area relationship (EAR). This was proposed more than a decade ago by Harte and Kinzig[5] and, they persuasively argued[6], is more appropriate than the SAR for estimating species extinctions, especially under non-random spatial distributions[7]. (A species is endemic if it is found only within some specified area.)

In their novel conceptualization of the problem, He and Hubbell[2] show that both the classic SAR and the EAR can be derived from a sampling theory based on spatially explicit patterns of individuals. Applying this approach to empirical data for woody plants in the rainforest and North American birds, which show typical patterns of spatial aggregation, they quantify the substantial discrepancy between backwards-SAR-based and EAR-based extinction rate predictions (finding overestimation as high as 160% for the plants). Importantly, the authors also justify the use of a simple approximation for the EAR that is robust to variation in species' spatial patterns and scale.

He and Hubbell, then, strongly question the use of SAR to estimate extinction rates not only from direct habitat loss, but also from projected species-range contractions expected to occur under climate change (see ref. 8 for an example). But they emphasize that their results do not in any way imply that there is not an ongoing mass extinction of species, nor that extinction debt is not a genuine biological phenomenon. Even with a better way to estimate rates of future species extinctions, there is still a need to obtain the data required to use the EAR to make more rigorous estimates. There is also the daunting problem of rigorously inferring extinction — showing that the last individual of a species has indeed died.

We invest heavily in infrastructure to store and make accessible the data we have, but by and large we have all but halted investment in discovering and describing the diversity of species with which we share the Earth. At best we have described only about 10% of all living multicellular species. If we 'fog' a tropical tree, literally hundreds of insect species unknown to science fall to the ground. Every year, many new species of even the best-known groups, the mammals and birds, are described. For only a fraction of the known species do we have even a rough idea of their entire geographical distributions.

Most of Earth's biodiversity occurs in tropical regions where species occur at low density and tend to have tiny geographical ranges. The first individual of such a species encountered in a brief inventory is not far from the last to go when extinction threatens, compared with populous, widespread species at higher latitudes. Thus, when modifying tropical habitat through forestry, mining or agriculture, we rarely have an idea which species inhabit the environment we are about to affect, nor the exact consequences of our action. The 'body bags' are rarely counted. ■

Carsten Rahbek *is at the Center for Macroecology, Climate and Evolution, Department of Biology, University of Copenhagen, DK-2100 Copenhagen, Denmark.* **Robert K. Colwell** *is in the Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, Connecticut 06269-3043, USA.*
e-mails: crahbek@bio.ku.dk; robert.colwell@uconn.edu

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ASTRONOMY

Bound and unbound planets abound

Two teams searching for extrasolar planets have jointly discovered a new population of objects: ten Jupiter-mass planets far from their host stars, or perhaps even floating freely through the Milky Way. **SEE LETTER P.349**

JOACHIM WAMBSGANSS

Two decades ago, we had no idea whether planets orbiting stars other than the Sun existed at all. Today, more than 500 exoplanets have been discovered, and the field of exoplanet research has advanced to become one of the most captivating branches of astronomy. Observational techniques now aim to address questions such as what the atmosphere and weather are like on some of these planets, and to determine their global statistical properties. On page 349 of this issue, the MOA and OGLE research teams[1] provide an exciting result for exoplanetary science: the discovery of a population of planets that have roughly the mass of Jupiter and separations from their putative host stars of at least ten times Earth's distance to the Sun.

The teams' finding[1] is based on gravitational microlensing, an established technique for detecting exoplanets that is well placed for statistical studies of exoplanets. There are two particularly exciting aspects to the discovery of this new exoplanetary population. The first is the authors' conclusion that, on average, there is more than one Jupiter-mass planet per Milky Way star. The second is the evidence that these planetary-mass objects could be at great distances from their host stars. Some of them could even be floating freely through the Milky Way — that is, they might not be gravitationally bound to any star at all.

Gravitational microlensing is one of a suite of planet-search techniques. The methods are truly complementary to one another, each probing different planetary properties and having its own particular strengths[2]. But most of them detect and explore nearby exoplanets. By contrast, microlensing probes more distant planets, using the host star–planet system as a magnifying glass. When a foreground star (the lens) passes in front of a distant, background star, the latter is magnified and displays a characteristic 'light curve'[3]. The two observables that characterize such a microlensing event are the height of the light curve's magnification peak and the duration of the magnification, which depends, among other parameters, on the mass of the lens: the lower the mass, the shorter the duration. Originally proposed as a way of searching for dark matter, it soon became clear that microlensing could also be used to detect planetary systems[4]: a planet orbiting the foreground star would produce a secondary peak in the light curve (Fig. 1).

Microlensing offers two advantages over other methods: it has the potential to yield the most representative statistical sample of Milky Way planets and it is, in principle, sensitive enough to detect Earth-mass objects[5,6] with current technology. However, the downside is that microlensing events are rare: fewer than one in a million stars in the central part of the Milky Way are microlensed at any given time by a foreground lensing star. And even if every such lensing star had a Jupiter-mass planet at a few times the Earth–Sun distance, only about 1% of these planets would be detected, owing to the exact geometric alignment required between the background star, the planetary system and an observer on Earth. So discovering such microlensing events is akin to finding a needle in a haystack.

To tackle these statistical challenges, a handful of independent research teams have developed advanced techniques to monitor the brightness of about 100 million Milky Way stars every few days. These techniques have allowed the teams to routinely find about