

NEWS & VIEWS



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South Africa's Cape region — the nation is steward of an impressive but imperilled biological heritage.

CONSERVATION BIOLOGY

The diversity of biodiversity

Arne Ø. Mooers

Species richness is not the same as evolutionary richness. So which is the better measure for setting conservation priorities? The flora of the Cape of South Africa provides a test for that pressing question.

South Africa's distinctive flag symbolizes its diverse cultural heritage. The nation's biological heritage is no less impressive: whereas the British Isles is home to about 1,500 plant species, South Africa's Cape region houses more than 9,000 in one-third of the area, with perhaps the highest concentration of endangered plant species anywhere in the world¹. On page 757 of this issue, Forest *et al.*² report how an evolutionary approach to plant conservation might lead to surprising choices among conservation areas. The study brings the concept of what might be called evolutionary heritage into sharp focus.

The species is the fundamental unit of biodiversity, and so the most common conservation approach is to concentrate resources in the most species-rich areas. This assumes that all species are equivalent, but species vary dramatically in their evolutionary isolation³.

Most have many and similar brethren (there are 3,400 members of the rose family, for instance), whereas some have only distant relatives (the evergreen shrub *Amborella trichopoda* seems to have no close relative among the entire ensemble of flowering plants). Biodiversity is not just the number of species but also the differences between them (Fig. 1, overleaf), and it seems intuitively obvious that both number and difference should inform conservation decisions⁴. Indeed, algorithms that select areas to maximize the evolutionary divergence among species in a particular region are several decades old⁵.

Intuition is fine, but theoretical work⁶ has cast doubt on the need for such algorithmic approaches: species richness works well because areas with more species in a group generally also contain more of the group's total diversity. Given that measuring evolutionary

divergence is costly, the cheaper approach of using species counts might be sufficient. Furthermore, whereas species number is a straightforward metric, it is not clear exactly what one would be conserving if one focused instead on evolutionary divergence. Forest *et al.*² confront both these issues with data.

Using an evolutionary tree linking the entire Cape flora and a comprehensive map of where each genus (species grouping) occurs naturally, Forest *et al.* compare genus richness with total evolutionary divergence (see Fig. 1 of the paper on page 758). The pattern they discover in South Africa is the sort that maximally decouples taxonomic richness (here, of genus rather than species) from total evolutionary divergence. In the western region, repeated evolutionary radiations — rapid bouts of evolution leading to many species — have led to mind-boggling numbers of taxa. The common

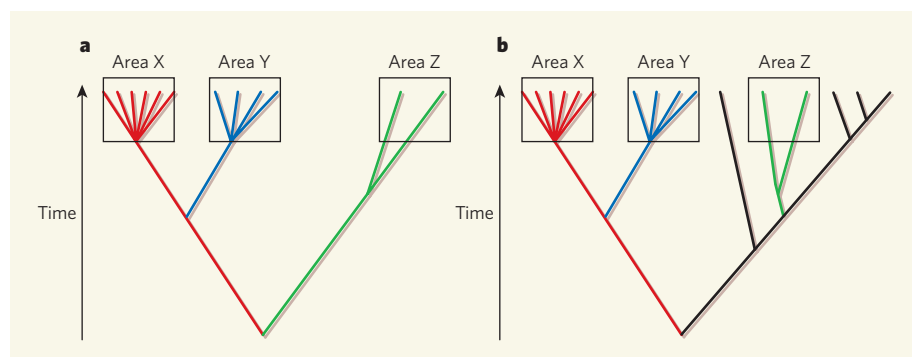


Figure 1 | Species diversity and evolutionary diversity. **a**, The evolutionary tree linking a set of hypothetical species found in three areas. Area X contains the most species and maximizes the total path along the evolutionary tree (in red). Area Y adds more species (blue), but area Z adds more unique evolution (green) to the tree linking the species in the three areas; so areas X and Z are priorities for preserving evolutionary heritage. **b**, The geographical scope is expanded and more of the tree is considered. If it turns out that species related to Z are already conserved (black), Y becomes the better choice for conservation. In terms of the Cape of South Africa, as studied by Forest *et al.*², areas X and Y represent the western region, and area Z represents the eastern region.

approach of maximizing the total number of conserved taxa would thus dictate choosing successive plots in the west. However, these genera are often each others' closest relatives. In the eastern region, the Cape vegetation meets and blends with another distinct floral assemblage (Maputoland–Pondoland–Albany), and plots are mixtures of more divergent genera. The maximum total evolutionary diversity measured in millions of elapsed years is retained with a mix of plots from both regions. The pattern of getting more divergence from fewer total species held even when Forest *et al.* estimated evolutionary divergence using a simpler (and so cheaper) taxonomy instead of their new evolutionary tree.

As the authors point out, the pattern predominant in the west (many closely related genera in the same area) is exactly what one would predict for areas that have seen repeated evolutionary radiations. Perhaps this is the pattern in other particularly species-rich areas of the world, for example in the intertidal areas of the northwest Pacific, or the tropical regions of the New World.

But how is preserving a larger slice of evolutionary diversity better than preserving more taxa? Forest *et al.*² test an argument based on future utility⁷. They first identify all the genera in their evolutionary tree that are already known to have economic uses somewhere in the world. These genera are widely dispersed across the tree, and they show that maximizing evolutionary divergence captures more of these genera than would random choice. In fact, because taxa in an area set aside for conservation will often be more closely related than they would be from random expectation, the authors' comparison is probably conservative. If so, then evolutionary divergence might be a far better approach than species richness if South Africa wishes to preserve the largest number of potentially useful taxa. Because the plots used here were so much larger (750 km²) than most real preserves, we must wait for a

more detailed data set to test this prediction directly.

The authors show both how and why a single country might best attend to its own evolutionary heritage. But the result presents a conservation conundrum. Of the bewilderingly many plant species in the Cape of South Africa, more than 6,000 are found in no other country in the world. The majority of these are in the western region. In contrast, the significant evolutionary diversity identified in the east is due in part to genera that are also found in neighbouring countries (Fig. 1). From the international perspective, perhaps South Africa should

concentrate on its relatively closely related but exclusive western flora, and hope that Mozambique, Swaziland and so on will steward more divergent but shared taxa.

The issue of national interest and shared conservation responsibility is obviously not unique to plants, or to South Africa⁸. For example, the South Pacific island of New Caledonia is the sole home of both *A. trichopoda* and the endangered kagu, a bird whose closest relative is in an entirely different family. The iconic polar bear's fast-melting range spans half-a-dozen countries. Given differences in law, in priorities and in resources among nations, and given the current strain on the biosphere everywhere, the issue of who is responsible for what aspects of diversity is at once scientific, political and urgent.

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ANALYTICAL CHEMISTRY

Sense and versatility

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Molecules that detect chemicals are the workhorses of analytical devices, but most recognize only one kind of target. A molecular sensor has now been devised that measures the concentrations of several metal ions.

What do the following things have in common: industrial effluents in a lake, signalling pathways in a cell and the blood status of a patient? The answer is that they can all be monitored by studying the concentrations of metal ions. There is a growing need for metal-ion detection, and one way of addressing this is to make sensors work harder. Writing in *Angewandte Chemie*, Schmittel and Lin¹ describe an impressive multitasking sensor — a molecule that binds to ions so that they can be interrogated with four different analytical techniques. This versatility allows the sensor to distinguish between various metal ions and to quantify their concentrations (Fig. 1).

Three of the detection techniques — referred to as channels — used by the authors have

previously been individually established as ion-sensing methods. The first sensory channel detects the colour change of an indicator upon ion binding, a method that dates back to at least a century ago². The second channel observes changes of luminescence. Many luminescent molecules emit a different intensity or frequency of light on binding to a metal compared with when they are metal-free, and these changes can be predictive of the type of metal that is bound³. The third channel senses changes in the electron density of molecules, brought about by the binding of metal ions. Such electrochemical behaviour is related to the reducing or oxidizing (redox) ability of the molecule⁴, and is also a good sensory pathway.