valuable ideas. Furthermore, an interesting and engaging Q&A session can lead to ongoing discussions, and thereby facilitate successful collaborations and future invitations to speak; meeting organizers tend to invite speakers they have had positive experiences with before. A good Q&A session and ensuing discussions during the coffee break also help to develop the professional network of the presenter.

Finally, reflecting on the questions asked during the Q&A session not only will enable the presenter to improve future talks by adjusting the content or approach of the presentation, but also might generate new ideas to improve his or her own research.

In summary, a well-conducted Q&A session can contribute to a mutually beneficial situation in which the presenter and the audience walk away from a scientific talk with new ideas and renewed enthusiasm for research.

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To protect and save

A new chapter opens on biodiversity conservation

Philip Hunter

In the wake of the admission from the United Nations (UN) that, to date, efforts have failed to even slow down the rate of extinction across almost all plant and animal taxa (CBD, 2010), the fight to reverse the human-induced loss of biodiversity is entering a new chapter. The failure to achieve the targets set in 2002 for reducing decline has led to a revised strategy from the Campaign for Biodiversity (CBD). This new approach recognizes that species conservation cannot be treated in isolation from other issues facing humans, including climate change, water scarcity, poverty, agricultural development and global conflict. It also acknowledges that declining biodiversity cannot be tackled properly without a more accurate inventory of the species in existence today. Thus, a large part of the strategy to combat species decline focuses on building an exhaustive catalogue of life.

The Global Strategy for Plant Conservation includes such a plan. The intention is to compile an online flora of known plants by 2020, which should enable comprehensive conservation efforts to gather steam. Peter Wyse Jackson, president of the Missouri Botanical Garden in the USA, said that around 25% of the estimated 400,000 plant species in the world, are thought to be threatened. He said that around 850 botanical

gardens have, between them, collected around 100,000 species, but only a quarter of these are from the threatened group. "World Flora online will then be an essential baseline to determine the status of individual plant species and threats to them," Jackson explained. "By 2020 it is proposed that at least 75% of known threatened plants should be conserved both in the wild and in existing collections."

...an online flora of known plants [...] should enable comprehensive conservation efforts to gather steam

Missouri Botanical Gardens will have an important role in the project and Jackson commented that the first step of the plan has already been achieved: the establishment of an online checklist of flora that is needed to build a comprehensive database of the plant species in the world.

Yet, some other plans to halt species decline have drawn criticism. "In my opinion, whilst such international targets are useful to motivate individuals, states and wider society to do conservation, they are not necessarily realistic because they are often 'pulled out of the hat' with very little

science behind them," commented Shonil Bhagwat, senior research fellow at the School of Geography and the Environment at Oxford University.

The revised CBD plan specifies measures for reversing the decline in biodiversity. One target is to enlarge protected areas for wildlife, within which activities such as logging are prohibited. Ecological corridors could then connect these areas to allow migration and create a network of 'safe' places for wildlife.

Such a corridor is being created between two parts of the Brazilian Atlantic rainforest—the Pau Brasil National Park and the Monte Pascoal National Park—both of which are already protected. "Well-managed protected areas keep away biodiversity threats, such as deforestation, invasive species, hunting and poaching," explained Arnd Alexander Rose, marketing manager for Brazil at The Nature Conservancy, a conservation organization that operates on all continents. "We think that the connectivity between the national parks is essential for the long-term permanence of local species, especially fauna," Rose said.

Worldwide, only around 6% of coastlines are within protected areas, but around 12% of the total land area is protected—a figure that is perhaps higher than many would expect, reflecting the large size of many national parks and other designated wildlife zones. Nevertheless, the coverage of different habitats varies greatly: "Only 5% of the world's temperate needle-leaf forests and woodlands, 4.4% of temperate grasslands and 2.2% of lake systems are protected" (CBD, 2010). The aim of the CBD is to increase the total area of protected land to 17% by 2020, and also to expand the protected coastal zones, as well as extending the area of protected oceans to 10%.

Things at sea, however, are different; both in terms of biodiversity and protection. The biggest threat to many marine species is not direct human activity—poaching or habitat encroachment, for example—but the impact of increased ocean acidity due to rising atmospheric carbon dioxide levels. Halting or reversing this increase will therefore contribute to the marine conservation effort and biodiversity in the long term.

However, the first task is to establish the extent of marine biodiversity, particularly in terms of invertebrate animals, which are not well catalogued. Ian Poiner is CEO of

the Australian Institute of Marine Science and chair of the steering committee for the first Census of Marine Life (Census of Marine Life, 2010), which has revealed the enormity of our remaining uncertainty. "So far 250,000 species [of invertebrates] have been formally described, but at least another 750,000 remain to be discovered, and I think it could be as many as 10 million," Poiner said. As evidence for this uncertainty he points to the continuing high rate of discovery of new species around coral reefs, where each organism also tends to come with a new parasite. The situation is compounded by the problem of how to define diversity among prokaryotes.

Even if the number of non-vertebrate marine species remaining to be discovered turns out to be at the low end of estimates, Poiner points out that the abundance and diversity of life in the oceans will still be far greater than was expected before the census. For fish—a group that has been more extensively analysed than invertebrates—Poiner notes that there are several thousand species yet to be discovered, in addition to the 25,000 or more known species.

The levels of diversity are perhaps most surprising for microorganisms. It was expected that these organisms would be present in astronomically large numbers—they are thought to account for 50–90%

of the biomass in the oceans, as measured by total amount of carbon—but the high degree of genetic divergence found within even relatively small areas was unexpected. "We found there are about 38,000 kinds of bacteria in a litre of sea water," Poiner said. "We also found that rarity is common, especially for microbes. If you take two separate litre samples of sea water just 10 or 20 kilometres apart, only a small percentage of the 38,000 bacteria types in each one are of the same kind. The challenge now is to find out why most are so rare."

This mystery is confounded by another result of the census: there is a much greater degree of connectedness than had been

expected. Many fish, and even smaller invertebrate species, travel huge distances and navigate with great accuracy, rather like migratory birds. "Pacific white sharks will travel long distances and come back to within 50 metres from where they started," Poiner said, by way of example.

The behaviour of the sharks was discovered by using new tags, measuring just a few centimetres across, that can be attached to the heads of any large creatures to track their location and measure temperature, conductivity—and thereby salinity—and depth. For smaller creatures, such as baby salmon, a different technology is used that involves the attachment of passive acoustic sensors to their bodies. These trigger a signal when the fish swim through arrays of acoustic receivers that are installed in shallower waters at locations throughout the oceans.

Although tagging and acoustic monitoring are providing new information about the movements and interactions of many species throughout the oceans, the huge task remains of identifying and cataloguing those species. For this, the quickly maturing technique of DNA barcoding has been useful and provides a relatively inexpensive and convenient way of assessing whether a specimen belongs to a new species or not. The method uses a short DNA sequence in the mitochondrial gene for cytochrome c oxidase subunit 1 (CO1)—around 600 base pairs in most species—which differs little within species but significantly between them (Kress & Erickson, 2008).

The Marine Census programme involves several barcoding centres that have determined barcodes for more than 2,000 of the 7,000 known species of holozooplankton, for example (Census of Marine Zooplankton: <http://www.cmarz.org>). Holozooplankton are small, completely planktonic invertebrates—which spend their lives floating or swimming in open water—and are a particularly sensitive marker of environmental changes such as ocean warming or acidification.

DNA barcoding can also be applied to prokaryotes, although it requires alternative sequences owing to the lack of mitochondria. In addition, horizontal gene transfer and uncertainty about how to define prokaryotic species complicate the task of cataloguing them. Nevertheless, by targeting a suitable core subset of a few genes, bacteria and archaea can be identified quite

accurately, and barcoding can increase our knowledge and understanding of their behaviour and evolution.

Such techniques could be applied to the identification of marine prokaryotic species, but Poiner argues that they need further refinement and will probably need to be combined with analytical methods that help estimate the total diversity, given that it is impossible to identify every single species at present. Indeed, the task of assessing the diversity of even land-based microorganisms is difficult, but such cataloguing is a prerequisite for accurate assessment of their response to environmental change.

"There is a general rule that the smaller things are the less we know about them," commented Stephen Blackmore, Regius Keeper of the Royal Botanical Gardens in Edinburgh, UK, a leading centre for conservation research. "I think it is very difficult or too early to say how biodiversity at the microscopic level is being impacted. Some of the newer approaches using DNA diversity to see, for example, what microorganisms are present in soil, will be important."

In the immediate future, advanced DNA analysis techniques have a more urgent application: the identification of genetic diversity within eukaryotic species. This is important because it determines the ability of populations to cope with rapid change: a species with greater genetic diversity is more likely to have individuals with phenotypes capable of surviving changes in habitat, temperature or nutrient availability. Genetic evidence will help to determine the secret of success for many invasive species of plants and animals, as they have already adapted to human influence.

"A major emerging theme is to look at the genetic diversity present in wild plant populations and to try to correlate this with identifying the populations that are best suited for coping with climate change," Blackmore said. "But it's a very new field and so far not much is being funded. Meanwhile, the immediate prospect is that plants will continue slipping away more or less un-noticed. Even where the landscape appears green there is generally a steady erosion of plant biodiversity going, on driven by the shrinking of natural habitats, the encroachment of invasive species, climate change and land management practices."

Yet Blackmore is optimistic that knowledge of how to preserve biodiversity is increasing, even for less adaptable species.

"We know how to, for example, grow food crops in ways that are more beneficial to biodiversity, but the desire for the cheapest food means that uptake is too limited. We know how to do most of the things needed to protect biodiversity. Unfortunately they are not being done."

There is hope, though, that increased understanding of biodiversity as a single, interconnected problem—rather than a series of unrelated hot spots and particular species—will lead to more coherent strategies for arresting global decline. The fate of flowering plants, for example, is intimately tied to their pollinators and seed dispersers.

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Most land animals in turn depend directly or indirectly on plants. "Since plants are the base of the food chain in all terrestrial environments, the threats to animals are increasing even more rapidly than those to the plants they depend upon," Blackmore noted. "It is still the case, however, that most conservation action is framed in terms of charismatic animals—such as tigers, whales, polar bears and pandas—rather than on the continuation of the kinds of place they require to live in."

Due to human nature, this 'cute' framing of the problem is perhaps inevitable. However, if it creates a groundswell of public concern leading to voluntary involvement and donation towards biodiversity conservation, then all species might benefit in the end. After all, animals and plants do not respect arbitrary human boundaries, so an ecological corridor and protected habitat created for tigers will also benefit other, less 'cuddly' species.

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