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Research Opinion

Making the case for plant diversity

Paul Smith*, John Dickie, Simon Linington, Robin Probert and Michael Way

Seed Conservation Department, Royal Botanic Gardens Kew, Wakehurst Place, Ardingly, West Sussex, RH17 6TN, UK

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Abstract

The Millennium Ecosystem Assessment estimates that between 60,000 and 100,000 plant species are threatened with extinction–equivalent to around one-quarter of the total number of known plant species. Why should we care? There are a number of reasons. The first is that these plants may be useful to us in unknown ways. Secondly, ecology has taught us that resilience is found in diversity. Thirdly, we should be saving plant species from extinction because we can–there is no technological reason why any plant species should become extinct. Where we can't protect and manage plant diversity *in situ*, we should be employing *ex situ* conservation techniques, ranging from seed banks to habitat restoration. The Millennium Ecosystem Assessment describes such interventions as 'techno-gardening'. This is not an abstract concept–it is already a reality in the majority of man-managed landscapes. In this context the perception of *ex situ* conservation as simply a back-up strategy for *in situ* conservation is mistaken. We are all involved in *ex situ* conservation to some degree, from cultivating our back gardens, to farming, to management of protected areas. *Ex situ* conservation should be seen as a complementary approach to *in situ* conservation and on the same spectrum. Kew's Millennium Seed Bank Partnership, comprising more than 120 plant science institutions in 50 countries, epitomizes this philosophy in action. We work actively on every seed collection we bank, finding out how useful it is and how we can grow it to enable human innovation, adaptation and resilience. Challenges remain at the policy level; for example, the need to factor-in the value of natural capital to development decision making, and better defining a role for public-sector science. At the technical level, also, there is much to do. Perhaps the greatest technical challenges relate to the restoration and management of complex, self-sustaining habitats or species assemblages. If we are to techno-garden effectively, in order to maintain ecosystem services and sustain biodiversity, then a multidisciplinary approach will be required. Many plant science institutions have recognized this and are becoming engaged increasingly in restoration activities and *in situ* management. Ultimately, humanity's ability to innovate and adapt is dependent on our having access to the full range of plant species and the alleles they contain.

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*Correspondence
Email: p.smith@kew.org

The problem of plant species extinctions

The extinction of species like the elephant bird, Tasmanian tiger and the once very common passenger pigeon have made little impact, but more charismatic species, such as the panda, gorilla and tiger currently stand on the brink. If we lose any of these species through our own carelessness, we will undoubtedly mourn their passing. However, the impact on humanity will be small – partly because, like us, they sit at the top of the food chain. With plants, the opposite is true. To the majority of people, plants are not charismatic – they aren't warm and cuddly, and they don't have big eyes that ask questions. And yet countless, non-descript plants have important roles in maintaining life on this planet. They sit at the base of the trophic pyramid, providing food all the way up the chain to us right at the top. They provide services such as climate regulation and flood defence. They contribute to soil formation and nutrient cycling, and they provide us with shelter, medicines and fuel. Despite this, the Millennium Ecosystem Assessment (2005) estimates that between 60,000 and 100,000 plant species are threatened with extinction – equivalent to around one-quarter of the total number of known plant species (Paton *et al.*, 2008). According to the Secretariat of the Convention on Biological Diversity (2010), the main threats are land-use change and over-exploitation, with climate change expected to exacerbate the situation. Why should we care? There are a number of reasons.

Why this matters

The first reason is that these plants may well be useful to us in unknown ways. The American naturalist, Aldo Leopold (1953), wrote 60 years ago:

> If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

Since Leopold penned those words, the scientific discipline of ecology has demonstrated time and again that all productive systems are built on a web of interrelatedness. This is manifest in the simple relationships between plants, pollinators, pests and predators in our agricultural systems but is true of all ecosystems, including the planet as a whole. We humans are not exempt from this. We are at the centre of this planet's ecology, and are becoming more and more dominant. A seemingly irrelevant plant may be essential to the life cycle of a pollinator. It may be the symbiont of a useful fungus or it may be home to an insect or bird that keeps a crop pest in check. A few decades ago we would have had no notion that the rosy periwinkle from Madagascar would contain the cancer-beating compounds of vincristine and vinblastine or that snowdrops from Turkey are a source of galanthamine useful in the treatment of Alzheimer's disease. We condemn plants to extinction at our peril.

A second reason why we should care is because ecology has also taught us that resilience is found in diversity. The farmer who plants just one crop is far more susceptible to the vagaries of climate or disease than the farmer who plants a range of crops with a range of requirements and susceptibilities. The problem is that as a species we have forgotten this. Increasingly, we rely on simpler systems and a rapidly dwindling range of plant diversity. Eighty per cent of our plant-based food intake comes from just 12 plant species – 8 grains and 4 tubers – this despite the fact that at least 7000 species of plants are edible (Grivetti and Ogle, 2000; Bharucha and Pretty, 2010). The Forestry Compendium (http://www.cabi.org/compendia/fc/) gives detailed information on around 1200 tree species that are used in commercial forestry throughout the world (*Pinus*, *Eucalyptus*, etc.), and with an estimated 100,000 species of tree currently available for use (Oldfield *et al.*, 1998), there is clearly ample room for innovation. In Western medicine, we have only screened 20% of the world's plant species for pharmaceutical activity, even though 80% of the people in developing countries use wild plants (many of them efficacious) for their primary health-care (Secretariat of the Convention on Biological Diversity, 2010). As the world grapples with the big environmental challenges of our day – food security, water scarcity, less land, climate change, deforestation, overpopulation, energy – we have to ask ourselves 'Can we continue to rely on such a tiny fraction of the world's plant diversity for all of our future needs?' Logic suggests that we can't. We will need new food crops that use less water or that are resilient to climate change. We will need to reforest catchment areas with more complex assemblages of trees that are not susceptible to pests and diseases. And we will need to develop first-generation biofuels that do not displace food crops.

Finally, we should be saving plant species from extinction because we can. With the range of techniques available to us, there is no technological reason why any plant species should become extinct. Where possible, we should be protecting and managing plant populations *in situ* – in the wild. Although some progress has been made in increasing protected areas globally (Secretariat of the Convention on Biological Diversity, 2010), we continue to degrade the land that we occupy and it is clear that providing legal protection to an area will not defend it from changes in climate, extreme weather events, invasive alien species and other impacts that require proactive management. Where we can't protect and manage plant diversity *in situ*, we should be employing *ex situ* conservation techniques, ranging from seed banks to habitat restoration. The Millennium Ecosystem Assessment (2005) describes such interventions as 'techno-gardening'. This is not an abstract concept – it is already a reality. In the United Kingdom we live in an entirely man-managed landscape in which species assemblages are a direct result of our impacts and needs. In this context the perception of *ex situ* conservation as simply a back-up strategy to *in situ* conservation is mistaken. We are all involved in *ex situ* conservation to some degree, from cultivating our back gardens, to farming, to management of protected areas. *Ex situ* conservation should be seen as a complementary approach to *in situ* conservation and on the same spectrum.

Kew's Millennium Seed Bank Partnership

The Millennium Seed Bank Partnership epitomizes this philosophy in action. Over the past 10 years, this

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partnership, comprising more than 120 plant science institutions in 50 countries, has successfully collected and secured in safe storage seeds from 1 in 10 of the world's plant species. Our next milestone is 25% of the world's plant species stored as seed by 2020. However, we don't just bank the seeds for posterity. We work actively on every single collection, finding out how useful it is and how we can grow it to enable human innovation, adaptation and resilience. We also send out seeds to non-commercial research organizations through our seed list (http://data.kew.org/seedlist/index.html) to underpin vital research in key areas such as water, energy, health, agriculture and biodiversity. However, as indicated above, there is much more to be done.

Challenges and solutions

At the policy level, we continue to see failure to account for the benefits provided by natural capital. Without factoring in the value of biodiversity and ecosystem services to development decision making, we are unable to manage those services effectively, resulting in biodiversity loss and degraded services (TEEB, 2009). Over recent decades we have also seen a significant reduction in public-sector investment in key technical areas such as plant breeding and seed science, as well as a dramatic shift in the private sector towards large, multinational seed companies (Fernadez-Cornejo, 2004). The results of this trend include a reduction in long-term, non-profit activities such as education and training of plant breeders, development of new methods of breeding, and germplasm preservation and enhancement (Acquaah, 2007). The decline in significance of the public sector in the development of plant-based products can partly, perhaps, be put down to the fact that, unlike physicists and medical scientists, we have not been good at coming together as multidisciplinary consortia to tackle the big problems. We tend to nibble away at the technical constraints without effectively articulating the big picture and the importance of our work to policy makers and funders. Given that the problems we are trying to address (hunger, water scarcity, deforestation, biodiversity loss) are huge and immediate, we have done a poor job in selling our skills. The Millennium Seed Bank Partnership has attempted to tackle this issue through emphasizing the 'think globally, act locally' philosophy. A technical network of 123 plant science institutions (virtually all of them in the public sector), comprising thousands of plant scientists, gives excellent opportunities for training and technology transfer, and packs a much greater punch than a single entity or a handful of institutions. One of the results of this approach has been the leveraging of significant public-sector funding for seed conservation in Europe, China, Australia and the USA.

At the technical level also, there is still much to do. The challenges in seed science research relating to understanding and manipulating the mechanisms of seed behaviour, dormancy, germination, viability and longevity remain, although good progress is being made. And the knowledge we are gaining in these areas has immediate application. In a recent project carried out by Kew and the Food and Agriculture Organization with a focus on difficult seeds (http://www.kew.org/science-conservation/conservation-climate-change/millennium-seed-bank/projects-partners/more-seed-projects/difficult-seeds-project_/), gene bank managers from 38 sub-Saharan African countries collated a list of useful species that they couldn't use effectively due to technical constraints. Of the 217 species identified, 151 were native species, including 33 native fruit trees. The majority of problems related to their use were poor germination (affecting 52% of the species identified) and handling or storage problems (38%). In the case of a well-adapted, low-input indigenous African fruit tree like *Schinziophyton rautanenii*, the knowledge that dormancy can be broken by smoke treatment removes the major technical impediment to its domestication. The Millennium Seed Bank Partnership publishes germination protocols via Kew's Seed Information Database which is available online (http://data.kew.org/sid/).

Perhaps the greatest technical challenges are in the restoration and management of complex, self-sustaining habitats or species assemblages. Habitat restoration is already well established as a discipline. However, there are huge gaps in our knowledge, particularly for complex tropical ecosystems, and there are not nearly enough practitioners out there learning what needs to be learnt. The Millennium Seed Bank Partnership is involved in habitat restoration projects in countries as diverse as Australia, Madagascar, South Africa, the USA and the UK. Our activities range from providing technical advice on seed collection, handling and storage (e.g. Madagascar), to providing seeds and information for species re-introductions (e.g. the UK, Australia and South Africa), to supporting full-scale habitat restoration (e.g. USA). If we are to techno-garden effectively in order to maintain ecosystem services and sustain biodiversity, then a multidisciplinary approach will be required. In particular, as mentioned above, the distinction between *ex situ* and *in situ* conservation approaches will become more and more blurred. Many botanic gardens have recognized this, and are becoming increasingly engaged in restoration activities and *in situ* management (Hardwick *et al.*, 2010).

Conclusions

There are many challenges ahead, and we have to be optimistic about our own ability to innovate and adapt. However, that adaptation is dependent on our having access to the full range of plant species and the alleles they contain. Our incentive is clear. It is our responsibility – the responsibility of *this* generation – to give our children every opportunity, and that means safeguarding and passing on our biological inheritance intact.

To find out more visit http://www.kew.org/science-conservation/conservation-climate-change/millennium-seed-bank/index.htm

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