MICROORGANISMS IN PLANT CONSERVATION AND BIODIVERSITY

Microorganisms in Plant Conservation and Biodiversity

Edited by

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FOREWORD

Plant conservation is increasingly recognised as an outstanding global priority, not only by scientists and committed conservationists but also by the global community and many governments. We know that tens of thousands of plant species throughout the world likely face extinction this century if current trends continue. The most comprehensive global list of endangered plant species produced to date was published by IUCN-The World Conservation Union in 1997 which documented almost 34,000 threatened plant species, and that work acknowledged that this is a considerable underestimation of the true figure of plant species threatened by extinction. Plant species loss is caused by many diverse factors, but primarily through the loss or damage of natural ecosystems and other impacts on wild plant populations and diversity caused by humankind, such as unsustainable collecting and uncontrolled invasions by alien species (plants, animals and microorganisms).

Despite considerable efforts made over the last few decades to safeguard the world's biodiversity in national parks, nature reserves and other forms of protected areas, we are today very much aware that despite our best efforts, the number of threatened species continues to rise. Innovative multi-disciplinary strategies in plant conservation are increasingly recognised as the best option for saving many species. We recognise that not only must we protect plants growing in the wild but also that we must seek recovery for an ever growing number of damaged plant populations and restore their habitats. Unless we gain a comprehensive insight into the factors that sustain these wild populations, our efforts to conserve diversity are ultimately likely to fail. The development of practical conservation and restoration methods, based on principles determined from the results of conservation biology research, is therefore an urgent priority.

The practice of plant conservation has for too long been a rather hit-or-miss mixture of methods. Species recovery work involving cultivation, reintroduction and restoration has often had to be undertaken without adequate knowledge of the underlying causes of endangerment or of the factors required to successfully recover a threatened species. While we have recognised that microorganisms are often a crucial and essential element in supporting the life-cycles of plant species, we have generally had to hope that our effort undertaken at a macro level will be sufficient to facilitate ecosystem functioning at the micro level. Many of our successful efforts in plant conservation have probably been as a result of good fortune rather than good science.

I greatly welcome therefore the preparation of this valuable book. With its focus on both the beneficial and detrimental importance of microorganisms (e.g. as mycorrhizas and pathogens), it provides an important review of the current state of knowledge on the importance and significance of microorganisms for plant conservation. I also hope that it will stimulate many more institutions to recognise that fundamental research on microbiology is an important element of plant conservation programs. The devastating impacts caused by the loss of biodiversity on our global environment and for the future of humanity can only be addressed if our future plant conservation efforts are based on understanding the complex interactions of biodiversity with its environment at all levels, rather than having to

rely on guesswork and good luck. This book should act as an extremely useful contribution to raising awareness of the importance of such aspects of plant conservation and provide an authoritative text to guide many plant conservation practitioners to the importance of microorganisms for successful plant conservation.

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March 2002

PREFACE

If 'all grass is flesh' and the productivity of plant systems is underpinned by the activity of microorganisms, then much of human existence depends upon the present biological diversity of microorganisms. Even the foundations of the industrialised societies of today – fossil oil and iron (the major source of the metal is from banded iron formations which formed when oxygen produced by microorganisms some 3,000 to 2,500 million years ago precipitated oxides of iron (Schopf 1999)) depend upon the past activities of microorganisms. Microorganisms are therefore not only the origin of life itself some 3.5 billion years ago (Shen *et al.* 2001) but they support much of the biotic, industrial and social fabric of today's world. As vital and integral components of the engine of existence, the diversity of microorganisms and the biological diversity they support are therefore fundamental in the debate to better manage the processes of conservation and threat abatement.

This book addresses the role of microorganisms in conservation – both their support functions and deleterious roles in ecosystem function and species survival. Importantly, a number of contributing authors highlight how microbial diversity is, itself, now under threat from the many and pervasive influences of man. What is clear from this volume is that like many contemporary treatments of plant and animal conservation, the solution to mitigate the erosion of biodiversity is not simple, made all the more complex by the lack of reliable taxonomic information, particularly for the predicted immense diversity of microorganisms.

The impacts of human activity touch all parts of the biosphere as highlighted by Egerton-Warburton *et al.* (this volume) and only now are some of the more advanced economies of the world coming to grips with the scale and inertia of the problem. The fate of an estimated two thirds of the plant species on earth now hangs in the balance (Anon. 2000). As man forges ahead monopolising biodiversity to a mere 100 plant species which represent the major human food and fibre species, another estimated 250,000 other plant species are in peril (Heywood & Watson 1995). With microbial diversity conservatively estimated in the millions of species, the impact of the loss of equilibrium of microbial diversity is daunting and potentially irreversible. Take for example the 'knock-on' effects on plant production systems if there is a careless disregard for maintenance of a diverse, healthy and functional microflora. Many agricultural systems do just this and to remain productive, require unsustainably high inputs of energy and chemicals. These inputs themselves further perpetuate the artificiality of the system, ultimately leading to a process of agricultural productivity devoid of natural inputs – essentially broad-scale hydroponics! Egerton-Warburton *et al.* (this volume) cite 90% of plant species as having some form of symbiotic association with fungi. How surprising is it then that other than a few esoteric examples in forestry, much of our broad-scale agricultural systems pay little or no attention to the role of helper fungi in maintaining soil and plant health?

The pivotal role of some microorganisms in maintenance of biodiversity is classically seen in the multifaceted benefits of ectomycorrhizas (Brundrett and Cairney this volume) in supporting a host of other organisms from bacteria and protists to invertebrates and vertebrates – including the elusive hypogeous fruit

bodies of truffles. If only similar prologues of the level of interaction of more microorganisms could be drafted before the loss of biodiversity eliminates taxa to the point where reconstruction of the intricate and elegant processes of ecological equilibrium is impossible. This book represents an attempt to bring to the fore the ecological underwriting provided by microorganisms. Let us hope that many more volumes will ensue as the value of microorganisms in conservation is recognised as part of the global conservation process.

References

Anonymous (2000) 'Gran Canaria declaration.' (Botanic Gardens Conservation International: Kew)

Brundrett MC, Cairney J (2002) Ectomycorrhizas in plant communities. In 'Microorganisms in plant conservation and biodiversity'. (Eds K Sivasithamparam, KW Dixon and RL Barrett) pp. 105–150. (Kluwer Academic Publishers: Dordrecht)

Egerton-Warburton LM, Allen EB, Allen MF (2002) Mycorrhizal fungal communities under elevated atmospheric CO_2 and anthropogenic nitrogen deposition. In 'Microorganisms in plant conservation and biodiversity'. (Eds K Sivasithamparam, KW Dixon and RL Barrett) pp. 19–43. (Kluwer Academic Publishers: Dordrecht)

Heywood VH, Watson RT (1995) (eds) 'Global biodiversity assessment.' (Cambridge University Press: Cambridge)

Shen Y, Buick R, Canfield DE (2001) Isotopic evidence for microbial sulphate reduction in the early Archaean era. *Nature* **410**, 77–81.

Schopf JW (1999) 'Cradle of life. The discovery of earth's earliest fossils.' (Princeton University Press: Princeton)

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