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INTRODUCTION TO ORCHID CONSERVATION

From the Greek god Dionysus to Darwin, orchids have fascinated countless generations with their inescapable beauty and beguiling forms. Whether it is their scent, sexual allure (for both insects and humans), or astonishing ability to grow in some of the most remarkable habitats on earth, it is no doubt that the orchid family—more than any other family of plants—has captured the human imagination. Their sheer diversity, with more species than any plant family, means they might not be that common; but there is an orchid likely to grow in just about any environment or habitat—from sub-Antarctic islands to searing granite rocks in the outback of Western Australia.

With so much diversity and exuberant evolutionary success, why are orchids also the single most endangered family of plants on earth? The answers to this are to be found in the pages of this book, as well as practical approaches currently available in orchid conservation techniques and technology. The concept for this book came from the inaugural International Orchid Conservation Congress (IOCC) held in Perth in 2001. Over time, and four IOCC conferences later, the book has grown to cover all aspects of orchid conservation with a focus on making orchid conservation technology accessible to all.

So why do we need a book on orchid conservation techniques? With 12% of the world's plants facing imminent extinction, and another 40% predicted to be extinct by 2050, never before has global biodiversity been under such threat. As we face the prospect of the sixth great extinction event, the challenge remains for conservation biologists, land managers, orchid enthusiasts, and growers to coordinate and link science and practice for more effective and targeted conservation outcomes. The task is large, and the time is limited. Orchid growers, admirers, and scientists have a special role to build the conservation technology toolkit and use these skills to conserve and reestablish wild orchid populations. Importantly, when engaging with stakeholders—whether they be landholders with orchids on their land, decision makers, or simply community members—dialogue is needed to forge links to deliver a level of conservation that will stem the impending tide of global extinctions threatening to engulf this remarkable family.

1.1 WHY ARE ORCHIDS RARE?

Orchids have significant below- and above-ground interactions with the living and abiotic environments. Few other families have such a diversity of synergies with other organisms: below ground, fungi and bacteria inhabit roots, rhizomes, and stems to assist with

nutrient acquisition, immunity, and germination; above ground (and below ground in Australian underground orchids), pollinators from birds to bees, wasps, moths, and butterflies are sometimes rewarded; more often than not, they are duped into shifting orchid pollen around the landscape. With over 25,000 species globally, these critical biotic associations may have played major roles in driving the astonishing diversification of the family, but at the same time, the dependence of orchids on these interactions for sexual reproduction and seed germination through to maturity often results in populations that are highly dispersed, limited in abundance, or vulnerable to even the slightest change in habitat conditions. As a result, such species face heightened extinction risk, particularly from natural climatic shifts and human-induced change.

1.2 WHAT THIS BOOK MEANS TO ORCHID CONSERVATION

This book is structured to provide the reader with the capacity to develop a conservation program primarily for terrestrial orchids; nevertheless, many of the techniques apply equally to epiphytes. It would take an encyclopedia of books to review orchid science and conservation practice; however, this book is a navigation aid to getting started. Though each of these chapters provides stand-alone guidance, collectively they enable practitioners to undertake what were previously considered complex scientific procedures. These chapters are enriched with invited *Case Studies* that are relevant to illustrating key principles, along with success stories in orchid conservation that were written by world leaders in orchid conservation practice and science.

1.2.1 Chapter Outlines

Monitoring is covered extensively in Chapter 2. The how, when, and what to monitor has been integrated into demographic studies—understanding the recruitment cycle from seed germination to adulthood to senescence of the orchid plant. These life-stage transitions provide a firm foundation for understanding recruitment bottlenecks and where to prioritize conservation actions. Incorporated in Chapter 2 are four salient case studies that were provided by experts in the field. They show the conservation benefits of monitoring and demography studies including analytical approaches as applied by Raymond Tremblay and his colleagues. Chapter 2 concludes by demonstrating another important use of monitoring and demographic data in developing protective policies through processes such as *Red Listing* under the International Union for Conservation of Nature (IUCN).

Chapter 3 covers core aspects of orchid mycorrhizal ecology relative to conservation actions and planning. Though mycorrhizal ecology of orchids is one of the most wide-ranging and highly published aspects of orchid biology (outside of the orchid taxonomic literature), practitioner benefits of these research studies is often limited. In this chapter, we synthesize approaches used for mycorrhizal isolation and culture using appropriate media. A special case study on the newly emerging, but highly specialized field of isotopic discrimination is presented by Gerhard Gebauer and Julienne Schiebold. This tool enables understanding of orchid nutrition, with the case study providing a readable and up-to-date account of how to use this potent tool to understand the degree of mycorrhizal dependency in orchids—with some surprising outcomes.

Ex situ conservation methods are explored in detail in Chapter 4, where orchid seed sowing techniques are outlined—ranging from sterile to semi-sterile germination techniques and nursery sowing. Though techniques in orchid seed sowing harken back to the pioneering work of Lewis Knudson in the 1940s, techniques and media to solve issues with seed germination continue to develop and improve. This is illustrated by the outstanding case study of the industrial scale propagation of *Cypripedium*, in both China and Europe, which was once considered to have seed that is deeply dormant and difficult to germinate. Even though the mycorrhizal fungus remains elusive to culture, the techniques developed by commercial and conservation practitioners (often involving green pod culture or, for mature seed, exposure to oxidizing agents to remove testa-imposed dormancy) are now reliably producing many seedlings.

Following on from Chapter 4 is an exploration of *in situ* sowing and soil baiting techniques in Chapter 5. Based on the pioneering work of Hanne Rasmussen and colleagues, the use of seed baits placed into soil has revolutionized our capacity to determine mycorrhizal distribution in soil as well as isolating ecologically competent fungi from developing protocorms. Soil baiting is also a tool for auditing soils to assess orchid recruitment hotspots with the technique modified to also assess recruitment niches for epiphytic species.

Chapter 6 is an overview of the techniques for orchid culture, focusing on symbiotic approaches to the culture of terrestrial taxa where conservation issues are the greatest. Epiphytic orchids, on the other hand, are readily and reliably propagated—by the millions! Just walk into any big box store, florist, or nursery, and the abundance and diversity of epiphytic species on sale is a clear sign that culture techniques are well resolved for this group of orchids. Many terrestrial taxa are routinely propagated and grown with nurseries specializing in their local terrestrial species. A fascinating local capacity building case study showcases the use of these techniques in an integrated orchid conservation propagation project in Africa presented by Vincent Droissart and Tariq Stévart. However, some species remain stubbornly elusive to long-term culture, such as the sexually deceiving genus *Drakaea*, where it's distinct and unusual mycobionts decline under pot culture conditions.

A key tool in modern day orchid conservation is the translocation of propagated plants to safe or restored sites. In Chapter 7, successful translocation approaches are described with a short review on the principles of restoration ecology. Five case studies present success stories in orchid translocation including involving undergraduate students in North America by Lawrence Zettler; the role of the Atlanta Botanical Gardens in restoring habitats for orchid reintroduction; a Ph.D. research project in southeast Australia; restoration of *Cypripedium* in the mountains of Beijing; and finally, how an orchid enthusiast managed to repopulate meadows in Scotland with common and rare local orchids. Strategies, decision support tools, and policy frameworks for translocations are also presented in this chapter and in other parts of the book.

Orchids share a unique and unusual relationship with their pollinators with a high level of specialization by the orchid on particular pollinators explaining, in part, the extraordinary diversification of the family. Chapter 8 provides an overview of orchid pollination syndromes drawing upon the remarkably diverse literature on the subject—from apomictic taxa through to orchids engaging in sexual deception. We show how to assess pollinator presence and efficacy through floral baiting and how to interpret these findings in conservation planning when translocations occur into new habitats or restored locations. A case study by Xiaokai Ma and Yi-bo Luo demonstrate the role of flower color signal mimicry in

pollinator attraction and pollination success in the slipper orchid *Paphiopedilum micranthum*. Another by Colin Bower demonstrates the implementation of targeted field research approaches to the study of sexual deception in orchids.

Chapter 9 outlines genetic approaches for all aspects of orchid biology and conservation—drawing upon the wealth of molecular approaches to assess genetic diversity in orchid populations to describing fungal diversity. Detailed approaches and methodologies are provided which, though of a highly technical nature, will be of great value to research students and laboratories with molecular capacity. Included in this chapter are case studies of how molecular techniques can facilitate taxonomic resolution in difficult genera, assist with species identification of orchid tubers that are being illegally traded, and finally, target important genotypes for the cultivation of the enigmatic *Cypripedium calceolus*.

A fundamental tool in conservation where rare and threatened species are involved is the use of *ex situ* conservation through conservation germplasm storage (mycorrhiza, seed, and living collections). Though many orchid seed banks exist throughout the world, Chapter 10 highlights that standard approaches, though generally applicable to many species if not carefully assessed, can lead to seed viability decline in some species. The chapter provides an overview of approaches including how to secure high quality collections of orchid seeds, as well as innovations in alginate encapsulation of seed and mycorrhizal fungus. Storage of mycorrhizal fungi and maintenance of living collections are also included in this chapter. Case studies for a number of *ex situ* orchid conservation programs are presented by Jennifer Cruse-Sanders and Dennis Whigham.

1.3 EPILOGUE ON THE FUTURE OF ORCHID CONSERVATION

The need for orchid conservation is paramount if we are to leave to future generations the rich and wildly fascinating orchid legacy we all enjoy today. Without the effective conservation actions outlined in this book, threatening processes will continue to militate against the survival of rare orchids, resulting in their continued degradation and inevitable extinction.

Integrated conservation of orchids (where often disparate scientific and practical approaches are melded for the purpose of a conservation outcome) provides a balance between the priorities of the need for scientific research and the need for urgent action in light of the large and growing number of rare and threatened orchid species (see Figure 1.1). However, despite the clear need for such an approach, there is relatively little work published on integrated conservation of rare plants, let alone orchids, that encompass genetic analysis, biological and ecological research, and experimental reestablishment of populations. While these data are substantially less in the context of terrestrial orchids, the importance of such knowledge is clear and the time for action is *now*.

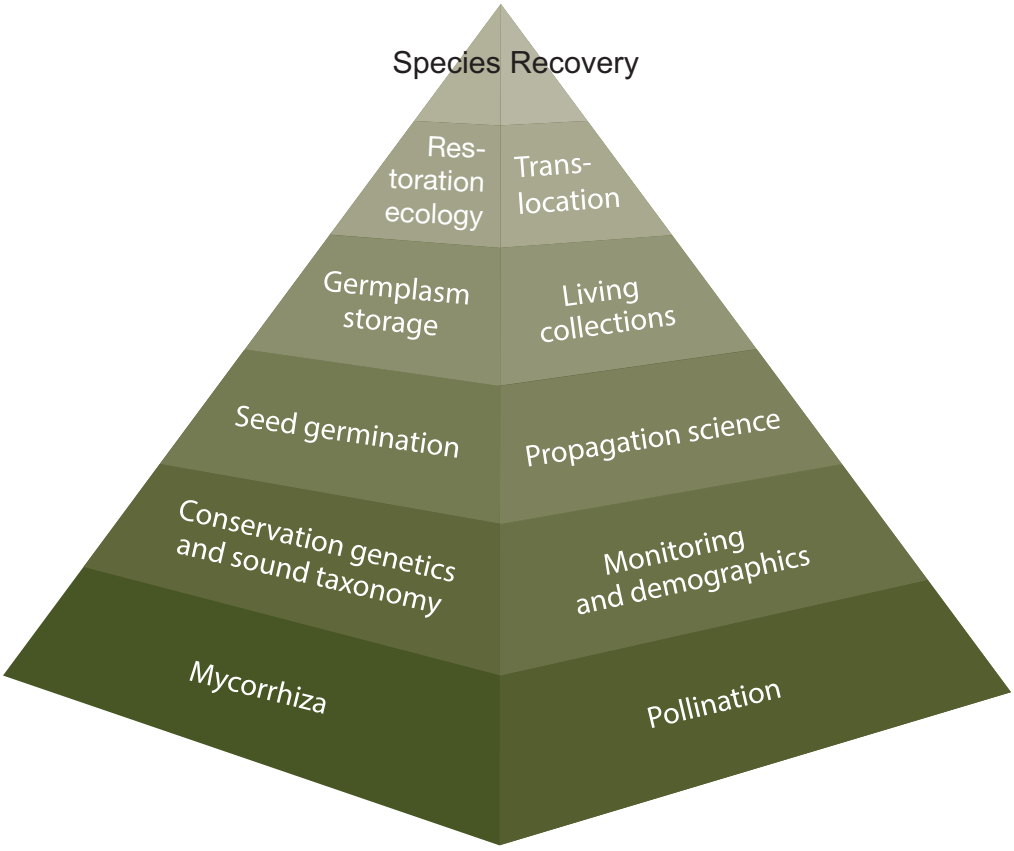

Figure 1.1 Concept model of integrated conservation relevant to orchids where individual scientific disciplines are linked to deliver effective and practical conservation outcomes