PREFACE

Harsh environments occur across the globe, often appearing as barren, desolate places incapable of supporting life. In reality, harsh environments are hotspots for biological diversity, supporting numerous rare and endemic organisms (Harrison & Rajakaruna, 2011; Myers et al., 2000; Nagy & Grabherr, 2009; Ward, 2008; Wharton, 2002). These habitats range from arctic and alpine environments to Mediterranean regions and inland deserts. Included are habitats with extreme soils such as serpentine, saline, sodic, and gypseous soils, as well as mine tailings and other metal-enriched soils.

Organisms that live in these environments must cope with extreme climatic variables such as solar radiation, temperature, and water availability. They must also cope with other abiotic stressors such as nutrient limitation, elemental toxicity, or extreme pH values. These environmental extremes necessitate novel adaptations for survival and act as both drivers of evolution and ecological filters, resulting in unique assemblages of organisms. The study of these habitats and the organisms that inhabit them have taught us much about evolution, ecology, and biology, and has provided insights into organismal response to climate change and other environmental perturbations, as well as insights into exobiology, biotechnology, restoration, and conservation. Studies of microbes and small invertebrates have received the most attention (*e.g.,* Horikoshi & Grant, 1998; Kushner, 1978; Liebezeit et al., 2000; Seckbach, 1999; Wharton, 2002), and a recent book focused mainly on animal adaptations (Lubzens et al. 2010); however, there is an extensive set of literature on plants, algae, and fungi found in harsh environments.

Many of the books on plant ecology and evolution in harsh environments focus on either a single extreme habitat (*e.g.,* Harrison & Rajakaruna, 2011; Nagy & Grabherr, 2009; Ward, 2008) or a single stressor (*e.g.,* Aroca, 2012; Lüttge et al., 2011; Turkan, 2011). In this book, we bring together a wide range of topics on ecology and evolution in harsh environments of plants (as well as a wide range of other non-animal organisms), with chapters written by experts from around the world. We begin with the creation of harsh environments, focusing on the roles of bedrock geochemistry and soil evolutionary processes in generating habitats with extreme abiotic conditions for photosynthetic and chemosynthetic processes (Chapter 1). Later chapters discuss the biology, ecology, and evolution of bryophytes (Chapter 12), vascular plants (Chapters 4-11), lichens (Chapter 3), herbivores and pathogens (Chapter 10), mycorrhizal fungi (Chapter 2), and other beneficial microbes (Chapters 1, 10) found in a range of harsh environments, including alpine and arctic settings (Chapter 7), fire-prone Mediterranean climates (Chapter 8), serpentine outcrops (Chapters 2, 3, 6, 10, 11, 13-15), gypsum soils (Chapters 2, 5, 14), metal-rich mine tailings (Chapters 2, 3, 10, 11, 14, 15), and saline soils (Chapters 2, 4, 11). We highlight new tools and emerging techniques in high-throughput phenotyping, genomics, and phylogenetics and the role of these tools in developing our understanding of the patterns and processes of evolution in harsh environments (Chapters 4, 5, 9, 11). These techniques, combined with classical ecological approaches, including reciprocal transplant studies (Chapter 11), allow us to carefully examine adaptation to and evolution in harsh environments, even providing genomic insights to stress tolerance in plants with direct implications for agriculture, biotechnology, restoration, and conservation (Chapters 7, 9, 11, 13-15; Peleg et al., 2011). Finally, several lines of needed research are emphasized, from phylogenomics and population genomics to developmental genetics and comparative biology of non-model plants (Chapters 4, 5, 9, 11, 16). This research will improve our understanding of plant and fungal life found in extreme habitats, not only on Earth, but also extraterrestrial life that likely exists elsewhere in the universe. Due to the limited extent and patchy distribution of harsh environments, plants found in these habitats are particularly vulnerable to the effects of climate change (Chapters 7, 13) and other anthropogenic impacts (Chapters 14, 15). Many of these habitats have been given a protected status based on their unique biological diversity and have been subject to restoration efforts (Chapter 14); however, much work is needed to improve the efficacy of these conservation and restoration efforts. The studies summarized in this book highlight improvements in our understanding of the ecology and evolution of plants and fungi found in harsh environments, adding both tools and knowledge to our efforts to restore and protect these unique habitats and the organisms that occur there. In the final chapter of this book, we summarize additional areas of research needed to improve restoration and conservation efforts (Chapter 16).

REFERENCES

Aroca, R. (Ed.) (2012) *Plant responses to drought stress: From morphological to molecular features.* New York, NY: Springer.

Harrison, S. & Rajakaruna, N. (Eds.) (2011) *Serpentine: The evolution and ecology of a model system*. Berkeley, CA: University of California Press.

Horikoshi, K. & Grant, W. D. (1998) *Extremophiles: Microbial life in extreme environments.* New York, NY: Wiley.

Kushner, D. J. (1978) *Microbial life in extreme environments*. New York, NY: Academic Press.

Liebezeit, G., Dittmann, S. & Kröncke, I. (Eds.) (2000) *Life at interfaces and under extreme conditions. Developments in hydrobiology* Vol. 151. New York, NY: Springer.

Lüttge, U., Beck, E., & Bartels, D. (Eds.) (2011) *Plant desiccation tolerance*. New York, NY: Springer.

Lubzens, E., Cerdà, J. & Clark, M. S. (Eds.) (2010) *Dormancy and resistance in harsh environments*. New York, NY: Springer.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature* 403, 853-858.

Nagy, L. & Grabherr, G. (2009) *Biology of alpine environments*. New York, NY: Oxford University Press.

Peleg, Z., Apse, M. P. & Blumwald, E. (2011) Engineering salinity and water-stress tolerance in crop plants: Getting closer to the field. *Advances in Botanical Research* 57, 405–443.

Seckbach, J. (Ed.) (1999) *Enigmatic microorganisms and life in extreme environments.* Boston, MA: Kluwer Academic Publishers.

Turkan, I. (Ed.) (2011) Plant responses to drought and salinity stress: Developments in a post-genomic era. *Advances in Botanical Research* Vol. 57. London: Elsevier.

Ward, D. (2008) *The biology of deserts.* New York, NY: Oxford University Press.

Wharton, D. A. (2002) *Life at the limits: Organisms in extreme environments.* Cambridge, MA: Cambridge University Press.