Arid and semi-arid lands cover more than one-third of the earth’s terrestrial area and are typically characterized by rainfall scarcity, higher temperatures and evapotranspiration, salinization, nutrient-poor soil, and a paucity of vegetation cover. Climate modelling projects that the frequency and intensity of extreme environmental events in these regions will become increasingly higher in future climate scenarios. Revealing the adaptive strategies and mechanisms of dryland plants to extreme environments such as drought, salinity and heat has become a research hotspot and is of great relevance for utilizing appropriate practices for the conservation and management of dryland vegetation. Notwithstanding the enormous efforts of academic researchers, the difference in adaptive strategies between species and the variation of plant adaptability across environmental gradients still require more thorough and accurate investigations.

We gathered studies from all relevant fields, including plant–soil relations, water, and carbon and nutrient physiology, as well as species diversity and distribution patterns, for this Special Issue in order to deepen the understanding of the adaption of dryland plants to more extensive and frequent environmental stresses under projected climate change. The Special Issue comprises thirteen original articles that represent a brief overview of the latest research progress spanning a broad range of aspects related to the adaptation of plants to extreme environments in drylands.

Considering that the soil in drylands is characterized by water deficit, loose structure, and severe salinization, belowground processes, including microbial activity and community dynamics, biogeochemical cycling, and soil respiration, interact to affect many aspects of plant growth state and ecosystem function these areas. Based on the changes in soil microbial communities under mixed inorganic and organic nitrogen addition in temperature forests, the study by Ding et al. [1] suggested that different components of nitrogen deposition need to be considered when studying the effects of nitrogen deposition on soil microorganisms in terrestrial ecosystems. Along an urban–rural environment gradient, Shen et al. [2] found that pH, organic matter, and ammonium nitrogen were the main driving factors of the differences in soil ectomycorrhizal fungi community composition and diversity in oak forests. Fu et al. [3] evaluated the influence of salinity and oil contamination on the soil seed banks of three dominant vegetation communities in the Yellow River Delta and observed that the effect of soil salinity on soil seed banks was highly vegetation-dependent. By performing structural equation models, Jiang et al. [4] explored the influence of soil and vegetation properties on soil aggregate stability in desert communities and suggested that the soil stabilization process was mainly controlled by soil physicochemical properties and vegetation characteristics, but their relative importance varies with community types. Wang et al. [5] quantified the variability of soil respiration at different spatial scales and demonstrated the potential to predict the spatial variability of soil respiration based on the combination of soil abiotic properties and easily measured aboveground functional traits.

Understanding plant nutrition and carbon and water physiology under environmental stress in drylands can provide insights into the conservation and management of endemic
vegetation in water-limited areas. Qi et al. [6] compared the allocation of non-structural carbohydrates in *Quercus mongolica* Fisch. ex Ledeb. across different life stages of various tree and shrub growth forms at the xeric timberline. The findings presented in this study suggested that the shrub form was better able to adapt to a drier habitat, and the tree-to-shrub shift could contribute to the expansion of woody species distribution in drylands. Based on isotopic imprints, Qin et al. [7] studied the contribution of condensation water to the water budget in *Halostachys caspica* (M.Bieb.) C.A.Mey. plants inhabiting saline environments and the migration pathways of condensation water within the soil-plant-atmosphere continuum, and the results highlighted the interaction between soil salinization and condensation water on the water-related physiological processes of desert shrubs. Luo et al. [8] reported the effect of soil factors on the leaf stoichiometry of different halophyte shrubs in desert areas, and the results indicated that the nutrient utilization characteristic and its influencing soil factor differed among different functional groups of halophyte shrubs.

Dryland biodiversity is of tremendous global importance, yet there continues to be inadequate attention given to this major biome, which covers such a vast part of our world’s terrestrial surface. Luo and Gong [9] investigated the α diversity of desert shrub communities and evaluated the relationship between species diversity indexes and key climatic variables across 29 sites in Xinjiang, northwestern China. The study found that species diversity indexes varied across sites with contrasting hydrothermal conditions, and, in comparison to temperature, environmental water availability in relation to precipitation had more profound effects on the species diversity of desert shrub communities. Hu et al. [10] studied the genetic diversity and spatial distribution pattern of the *Quercus wutaishanica* Mayr population in the semi-arid Loess Plateau of China, and the intra-specific point pattern analysis revealed that the spatial distribution pattern of *Q. wutaishanica* individuals shifted with changing spatial scale in this ecologically fragile region. Liu et al. [11] explored the scale effects of the biodiversity–ecosystem multifunctionality relationship of representative desert plant communities in the southern margin of the Taklimakan Desert. They found that species diversity, functional diversity, and phylogenetic diversity dominated ecosystem multifunctionality at different scales, respectively.

The shift in species distribution under the backdrop of global change is one of the hotspots in ecology, especially in drylands where the environmental water availability for plants is sensitive to climate change. Liu et al. [12] tested the effect of salinity-related soil chemical properties on the species’ distributions of six *Kalidium* species in the arid and semi-arid areas of Northwest China, which provided clear indications of the major pedological determinants of the species’ geographic ranges and strong genotype-environment interactions among *Kalidium* species. Using the maximum entropy model, Zhang et al. [13] predicted the potential geographical distribution of the medicinal plant *Ephedra sinica* Stapf under anticipative climate change, and the model outputs suggested that the distribution barycentre of *E. sinica*, possessing important ecological value in desert community maintenance and stability, might migrate from its historical position to the southwest under future climatic scenarios.

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