Executive Summary

It's been stated that there is no technical reason for any plant species to go extinct, given the current knowledge and multiple options for facilitating both in situ and ex situ conservation (Smith, 2016). Indeed, efforts directed at both in situ and ex situ conservation are increasing, protecting habitats and creating extensive ex situ living collections and large seed banking efforts (Linsky et al., 2024; Liu et al., 2020). However, the projections are that the trajectory of species extinction will continue to rise (Antonelli et al., 2023), and the question becomes how quickly and effectively can conservation actions be applied to prevent extinction losses (Anderson et al., 2025)? For those species that require technologies beyond seed banking--the exceptional species--there is an additional layer of challenge.

This document provides a summary of the current state of exceptional plant conservation, specifically cryo-conservation, based on the *2nd Virtual Global Symposium and Workshop on Conserving Exceptional Plants: Cryobiotechnologies, Status, and Scale,* held April 8–9, 2025, and hosted by the Cincinnati Zoo & Botanical Garden's Center for Conservation and Research of Endangered Wildlife (CREW). It provides a snapshot of the current state of exceptional plant conservation cryo-banking, looking at the current methodologies, global capacity, technological challenges and opportunities that will be needed for scaling up efforts, and finally, evaluating the status, setting priorities, and filling gaps. For this document, the speakers from the symposium have provided short topical summaries of their talks, and each is followed by a link to the full talk.

Section I provides updates on current cryopreservation methodologies, organized around the tissue types that are most frequently used for cryo-banking. While short-lived seeds appear to be the least challenging, determining their short-lived status is less than straightforward. Pollen and spores have characteristics analogous to seeds and should be integrated into long-term ex situ conservation strategies, while for winter-hardy woody species, cryopreserving dormant buds can be an efficient and useful approach. Shoot tip and somatic embryo cryopreservation require additional protocols for developing in vitro cultures and methods for regrowing plants, but they can be useful when other methods are not workable. By matching the most efficient but effective approach to the appropriate tissue, these methods provide a versatile toolbox for approaching cryo-conservation.

However, even with effective methods, cryo-conservation of exceptional species will only be achieved through the efforts of multiple labs and researchers across the globe. **Section II** provides examples of labs around the world that have cryopreservation capacity and are using it for conserving exceptional species, including labs from Australia, Thailand, China, India, South Africa, Europe, Brazil, Mexico, and the United States. While only a snapshot of the full worldwide capacity, these examples provide insight into the different approaches and challenges found globally. In some cases, there is a high level of capacity and expertise, but their application is often heavily weighted toward crops in comparison to wild species. A map of these and additional labs with plant cryopreservation capacity is also provided at the end of this document.

One point of agreement among plant cryopreservation practitioners is that methods for developing and applying protocols to wild species are time- and resource-intensive and with increasing threats to plant biodiversity, current practice may not keep pace with extinction.

Section III presents examples of research that is working toward improving efficiencies that can help scale up cryo-conservation, from a key for identifying likely recalcitrant seeds, to methods for triaging seeds suspected as being short-lived, and approaches for decreasing the time and resources for in vitro work and cryopreservation protocol development. These talks highlight the need for additional, comparative studies to better understand the physiological mechanisms that underlie seed storage characteristics and allow or inhibit survival of tissues in vitro and through cryopreservation. Without this knowledge, scaling up cryo-conservation to the levels needed will not be achieved.

Section IV focuses on moving forward in exceptional species conservation. These talks describe current knowledge of which species are exceptional and its gaps, a framework for developing strategies for conserving exceptional plants, and the Global Plant Cryopreservation Initiative, a "long-term model" for cryo-conservation, focused around three crop species. Planning for exceptional plant cryo-conservation is very feasible, but it will require additional funding and capacity to achieve its goal.

These summaries and talks demonstrate that there is a mature scientific and technological foundation for conserving exceptional plants using cryobiotechnologies that forms the basis for the affirmation that there is no technological reason for any species to go extinct. There is a growing global network of laboratories with cryopreservation capacity that have an increasing awareness and eagerness to apply their expertise to exceptional plant conservation. While there is still a need for additional capacity, training, and focus on wild species, this increasing awareness is a hopeful sign. Information gaps still exist and additional research is needed to streamline the process of protocol development if the needed efficiencies are to be achieved, but new approaches for identifying likely exceptional species, for prioritizing target species, and for streamlining protocol development show promise. Additional support for these efforts should also develop from emerging information databases on in vitro and cryopreservation work and from AI and robotics technologies. What is needed is an overarching global strategy for harnessing these tools and scaling up efforts, as well as investments to support such work. We hope that this overview of the current state of exceptional plant cryo-conservation can help provide context as well as inspiration for both, to ensure that the conservation of exceptional plants is not left behind, and that the application of current and emerging knowledge can outpace the extinction crisis of the 21st century.

Full Document Coming Soon!