2020

North American Botanic Garden
Strategy for Alpine Plant Conservation

BETTY FORD ALPINE GARDENS
VAIL'S ALPINE TREASURE

DENVER BOTANIC GARDENS

2020

North American Botanic Garden Strategy for Alpine Plant Conservation

Authored by: Betty Ford Alpine Gardens, 522 S. Frontage Rd. E, Vail, CO 81657

Nicola Ripley, Executive Director

Nanette Kuich, Education Director

Denver Botanic Gardens, 1007 York Street, Denver, CO 80206

Jennifer Ramp Neale, Director of Research & Conservation

Mike Kintgen, Curator Alpine Collections

Rebecca Hufft, Associate Director of Applied Conservation

Amy Schneider, Horticulture Specialist

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FORWARD

The Global Strategy for Plant Conservation (GSPC) was developed due to the need for a global vision to protect plants. The GSPC initiated excitement and rallied conservation organizations and particularly botanic gardens to a joint plant conservation cause. As a result of the GSPC, other strategies, both international and country based, have been developed, all with specific objectives for conserving plants.

The following strategy is the first to use all available information to provide guidelines for protecting a specific group of plants, targeting those growing in the inhospitable land above the trees known as the alpine. While not as threatened by habitat loss and human activity as many other plant communities, the alpine environment appears to be particularly threatened by climate change. Conserving its flora now is critical because of differences being seen in pollinators, treeline levels and species composition. Located at 8,200 feet high in the Rocky Mountains, Betty Ford Alpine Gardens is uniquely positioned to spearhead an effort to conserve this fragile mountain environment.

I would like to thank Larry Stritch, National Botanist (retired), United States Forest Service, for first suggesting we combine forces to protect the alpine environment. Since then, Denver Botanic Gardens, and particularly Jennifer Ramp Neale, have partnered with Betty Ford Alpine Gardens to finalize this strategy and begin the implementation of its targets. Also a special thank you to Dawn Welles, PhD student, for her assistance with compiling and editing this document.

Nicola Ripley
Executive Director, Betty Ford Alpine Gardens

Cirsium spp. newly described species and bumble bee pollinator.
Photo Nanette Kuich

INTRODUCTION

The North American Botanic Garden Strategy for Alpine Plant Conservation (Alpine Strategy) is a blueprint for protecting alpine plants and ecosystems in the United States, Canada and Mexico, focusing on the role of botanic gardens in this effort. The strategy is based on two existing templates - The Global Strategy for Plant Conservation (GSPC),[1] first approved at the Conference of the Parties (COP) to the Convention on Biological Diversity in 2002, updated for the years 2011-2020[2] and the North American Botanic Garden Strategy for Plant Conservation (North American Strategy), written in 2006 and updated in 2016.[3]

The alpine zone encompasses vegetation above the natural high altitude treeline.[4] Plants that inhabit the North American alpine zone are vulnerable to climate change. According to a 2019 special report by the United Nations Intergovernmental Panel on Climate Change and Land, anthropogenic warming is projected to shift climate zones poleward and upward in regions of higher elevation. Worldwide, mean land surface air temperature has increased 1.53ºC from 1850-1900 to 2006-15. The report also states that desertification is expected to increase in semi-arid to arid drylands, including the U.S. Southwest that contains the Rocky Mountain alpine ecosystems. The result will be to lower ecosystem health, including losses in biodiversity. Invasive species are also likely to be aggravated by climate change.[5]

Hoosier Ridge, Colorado. Photo Mike Kintgen

Lewisia pygmaea. Photo Emily Griffoul

The American Pika

The American pika (*Ochotona princeps*) is a small mammal that lives exclusively in the alpine and is dependent on it for its survival. The pika is closely related to rabbits and hares, thriving above treeline in rocky, mountainous habitats of talus and scree fields with nearby alpine meadows. Their frequent shrill calls are usually the first indication that one is nearby, using the calls to alert others to the presence of danger. American pikas are generalized herbivores, feeding on alpine plants and selecting their forage based on its nutritional value. They are well known for haying - collecting plants during growing seasons and caching them in large haypiles. The haypiles are moved into burrows to serve as a winter food source, with up to 30 species of plants in a single haypile. Long-term population trends of pikas are being studied to assess how the species responds to a warming climate, with many populations showing documented declines in number. Protecting the alpine means protecting the whole ecosystem, including these furry creatures that depend on the alpine to survive.

American pika. Photo Gerhard Assenmacher

There is evidence of more amplified warming at higher elevations.[6] Significant altitudinal amplification trends were found for mountain locations in the U.S. Rockies and Appalachian Mountains as well as the Asian Tibetan, Loess, Yunnan-Guizhou and Mongolian Plateaus, the Alps of Europe, and the South American Andes.[7] NOAA data indicate that the American West has become 1.4º C warmer over the 100 period from 1908-2007, more than 0.5º C higher than the planet as a whole.[8] A 100-year study of temperature trends in Western Montana, which includes some Rocky Mountain alpine ecosystems, finds that the rise in extremes and seasonal averages has been two to three times greater than that of the global average.[9] At two high elevation sites in Colorado, temperatures increased an average of 1.2º C per decade over the period from 1983 - 2007.[10]

Scientific observations have found that alpine species abundance, richness, and distribution have been impacted by warming temperatures, resulting in altered patterns of alpine vegetation.[11] For example, 867 vegetation samples from 60 alpine sites in Europe show a decline in cold-adapted and an increase in warm-adapted species.[12] Research in the Italian Alps has found 52 alpine species to have upwardly migrated 23.9 meters/decade.[13] There has also been an observed 31-65% decline in abundance of arctic-alpine indicator species being monitored in Glacier National Park, Montana from 1989-2002.[14]

The Alpine Strategy provides a framework for North American botanic gardens to address the environmental and climate change challenges facing alpine ecosystems. It highlights the critical role that botanic gardens can play in research, conservation, and education. The Strategy is intended to encourage plant conservation organizations to contribute to the collective goal of conserving North American alpine plants and their habitats. Additionally, it fosters collaborative relationships among nations in North America, as plant conservation is often not as effective when separated by international boundaries.[3] The Alpine Strategy is intended for use by not only botanic gardens, but natural history museums, universities, governments, native plant societies, and any other organization interested in preserving the natural heritage and ecological integrity of alpine zones in North America.

Plant Conservation Efforts

The botanical community is increasingly working to conserve plants and their habitats in the face of continuing loss of plant diversity. Worldwide, between 60,000 and 100,000, or one-third of all plants, are threatened with extinction due to habitat loss, fragmentation, and degradation.[1,15] Strategies to address this plant extinction crisis by the

CASE STUDY
OBJECTIVE 2
TARGET 9

Collections for Conservation at Betty Ford Alpine Gardens

Situated at 8,200' (2,500m) elevation in the southern Rocky Mountains, Betty Ford Alpine Gardens is uniquely positioned to conserve alpine biodiversity in *ex-situ* collections, and currently has more than 3,000 species in its gardens from high elevation ecosystems all over the world, including more than 700 rare and threatened species. One of the most valuable and rare species is *Penstemon debilis*, Parachute Penstemon, a critically imperiled species endemic to Garfield County, CO. Only five populations remain in the wild, and they are at high risk of damage from oil and gas development. Betty Ford Alpine Gardens partnered with the Bureau of Land Management (BLM) to conduct census surveys, collect seed, and propagate this special plant to grow in the Gardens.This *ex-situ* collection helps to keep P. debilis from going extinct even if its habitat is further disturbed. About 80,000 species, or 30% of the world's plants, are grown in *ex-situ* collections in botanic gardens and arboreta, an important repository of diversity.

Penstemon debilis.
Photo Todd Winslow Pierce

Summit Lake drainage, Colorado. Photo Amy Schneider

Saxifraga chrysantha. Photo Amy Schneider

botanical community began at the international level with national and regional strategies soon joining global efforts.

The Global Strategy for Plant Conservation (GSPC)[2] is the hallmark of global plant conservation strategies. It was adopted in 2002 by the Convention on Biological Diversity and updated in 2012 to bring both awareness and a framework for policy and action to address threats faced by plants worldwide. The GSPC provides concrete global goals and objectives for plant conservation while also encouraging individual nations to develop their strategies to support the overall protection effort. This emphasis resulted in the North American Botanic Garden Strategy for Plant Conservation in 2006, updated in 2016[3], that laid the foundation for the protection of plants in North America.

Motivated by concern for alpine plants and their stewardship, representatives of a diverse group of botanic gardens (Betty Ford Alpine Gardens, Denver Botanic Gardens, the Canadian Botanic Gardens, Botanic Gardens Conservation International, and the Memorial University of Newfoundland) and the United States Forest Service joined together in 2010 to specifically address the conservation of alpine plants in North America. Its completion is presently being led by Betty Ford Alpine Gardens and Denver Botanic Gardens.

The more specific emphasis on alpine habitats of the Alpine Strategy is considered within the broader frameworks of the GSPC and North American Strategy and is seen as complementary to their goals and objectives. The Alpine Strategy notably places a stronger emphasis on *in-situ* conservation as a higher priority for alpine species, supported by *ex-situ* efforts because of the anticipated impacts on natural habitats from climate change and other environmental factors.

SUMMARY OF OBJECTIVES AND TARGETS

The Alpine Strategy has four objectives and twelve targets to guide botanic gardens in meeting the objectives, summarized below.

OBJECTIVE 1 — Understand and document alpine plant diversity.

TARGET 1. Develop a working map of all North American alpine areas by 2022.

TARGET 2. Create a list of all known alpine plants of North America that highlights alpine plants whose conservation status is ranked G1/T1 – G3/T3 by 2022.

TARGET 3. Assess land management designations for all North American alpine habitats by 2023.

TARGET 4. Provide online access to floristic inventories and research on North American alpine plants to minimize gaps in knowledge by 2030.

OBJECTIVE 2 — Conserve alpine plants and their habitats.

TARGET 5. Protect 50 percent of the most Important Plant Areas (IPAs) for alpine plant conservation in North America by 2030.

TARGET 6. Conserve at least 25 percent of all identified North American alpine flora *in-situ* by 2030.

TARGET 7. Conserve 60 percent of threatened alpine plant species in North America *in-situ* by 2030.

TARGET 8. Conserve 60 percent of all identified alpine plant species in North America *ex-situ* by 2030.

TARGET 9. Ensure that at least 75 percent of all identified threatened North American alpine plant species are held in *ex-situ* collections, and 10 percent are in recovery and/or restoration programs by 2030.

OBJECTIVE 3 — Promote awareness of the alpine ecosystem and plant diversity through education and outreach.

TARGET 10. Incorporate the irreplaceable value of the North American alpine ecosystem and plant diversity into educational and public awareness programs at botanic gardens by 2025.

OBJECTIVE 4 — Build capacity for the conservation of alpine plant species and associated habitats.

TARGET 11. Increase the number of trained professionals working on North American alpine plant conservation to address local, regional and national needs by 2030.

TARGET 12. Establish and strengthen networks, partnerships, associations and stakeholders for alpine conservation activities at regional, national and international levels by 2030.

TARGETS FOR BOTANIC GARDENS

OBJECTIVE 1. Understand and document alpine plant diversity.

TARGET 1. Develop a working map of all North American alpine areas by 2022.

A clear understanding of the distribution of North American alpine habitat is needed in order to protect alpine plant diversity. Using the definition of alpine as the treeless regions at the uppermost reaches of the mountains,[4] a map of alpine habitats in North America will be compiled using a GIS format. The map will include all areas that meet the narrow definition of alpine described as having a mean growing season temperature of <6.4ºC.[15,16]

TARGET 2. Create a list of all known alpine plants of North America that highlights alpine plants whose conservation status is ranked G1/T1 – G3/T3 by 2022.

A definitive list of online flora providing the scientific names for 300,000 species of plants has been created as a result of the work done for the Global Strategy for Plant Conservation (GSPC).[17] The list of alpine plants known to occur within North America will be built from various sources such as the online Flora of North America[18], the PLANTS database administered by the U.S. Department of Agriculture[19] and other alpine specific resources. Additional online resources will include the Global Observation Research Initiative in Alpine Environments (GLORIA),[20] and the Rock Garden Plant Database.[21] Online herbarium specimen databases covering areas that align with mapped alpine habitats such as the Global Biodiversity Information Facility (GBIF)[22] and iDigBio[23] will also be used.

The compiled list for alpine plant species within North America will be compared to the NatureServe database[24] to determine conservation ranks for all taxa. Those with a global rank of G1/T1 – G3/T3 will be highlighted.

TARGET 3. Assess land management designations for all North American alpine habitats by 2023.

Land ownership and management status will be compiled for all Target 1 mapped areas of North America. Areas will be classified based on IUCN protection designations:[25]

Category Ia — Strict Nature Reserve • **Category Ib** — Wilderness Area
Category II — National Park • **Category III** — Natural Monument or Feature
Category IV — Habitat/Species Management Area — **Category V** — Protected Landscape/Seascape [a] **Category VI** — Protected Area with sustainable use of natural resources

Land management designations will be determined and ranked based on current land management agency definitions for habitat protection and security of designation.

CASE STUDY
OBJECTIVE 1
TARGET 4

Using Herbarium Records to Track Climate Change in the Alpine

Phenology, the timing of biological events, is recognized as one of the best indicators of biological responses to climate change. Using observations of plant phenology, like the timing of flowering, we can track how plants have responded to climate change and predict future changes in plant communities. While we regularly record phenological measurements to understand seasonal and recent phenological patterns, at Denver Botanic Gardens we use herbarium specimens to look back in time and measure how plant phenology has changed over longer periods. Our 2018 publication "Using Herbarium Specimens to Select Indicator Species for Climate Change Monitoring," explains our process of doing so. Studying species in Colorado's alpine areas, we analyzed herbarium specimen data to look at flowering time over the course of a 61-year period and its relationship to temperature and precipitation. We found that, on average, species that showed earlier bloom times than in previous years bloomed 39 days earlier at the end of the 61-year study than at the beginning. This indicates the sensitivity of these species to climate change.

Hufft, R. A., M. E. DePrenger-Levin, R. A., Levy, and M. B. Islam. 2018. Using herbarium specimens to select indicator species for climate change monitoring. Biodiversity Conservation 27: 1487-1501.

Collection of herbarium vouchers in the alpine. Photo Dominique Taylor

Dryas octopetala. Photo Nick Courtens

TARGET 4. Provide online access to floristic inventories and research on North American alpine plants to minimize gaps in knowledge by 2030.

Existing data and studies will be compiled to provide comprehensive access to resources. This also allows for gaps in knowledge to be determined.

Areas where alpine botanical diversity is under-studied or poorly understood will be identified based on Target 1 and Target 3 mapping. Those areas needing further documentation and greater knowledge of the flora with the potential to improve conservation will be prioritized. Floristic inventories will be conducted through collections to enhance knowledge of alpine plant diversity and distribution. Specimens will be deposited in herbaria of the region where plants are collected. Specimen data will be shared broadly on publicly accessible platforms such as Global Biodiversity Information Facility (GBIF),[22] iDigBio,[23]Symbiota,[26] and the Southwest Environmental Information Network (SEINet).[27]

OBJECTIVE 2. Conserve alpine plants and their habitats.

TARGET 5. Protect 50 percent of the most Important Plant Areas (IPAs) for alpine plant conservation in North America by 2030.

An Important Plant Area (IPA) is a natural or semi-natural site exhibiting exceptional botanical richness and/or supporting an outstanding assemblage of rare, threatened and/or endemic plant species and/or vegetation of high botanic value.[28]

Protection of alpine plants will be increased by additional habitat conservation. Areas of high alpine diversity, particularly those with numerous occurrences of G1-G3 plants, will be highlighted as IPAs. The Native Plant Conservation Campaign's IPA Program[29] and the Colorado Natural Heritage Program methodologies for IPA identification[30] will be utilized in alpine areas of North America. Once North American alpine IPAs have been designated, they will be further ranked based on level of protection following the IUCN Protected Area Management Categories.[25] Botanic gardens will work with land managers to protect at least 50 percent of these areas.

The broad goal is to maintain or improve the management of protected areas to achieve a favorable conservation status for alpine plant species. While only public land management organizations can control the level of protection on various parcels, the scientific community can work to provide the agencies with robust, sound data on which to base management decisions. Success will involve collaboration among botanic gardens and public land management agencies.

Lupinus sp. Mt Hood, Oregon. Photo Mike Kintgen

TARGET 6. Conserve at least 25 percent of all identified North American alpine flora *in-situ* by 2030.

Following Target 5 identification of IPAs, it will be verified that 25 percent of North American alpine plants are located in protected areas. Areas that are designated as IPAs with low protection designation and areas with high alpine flora diversity not included in IPAs will be targeted for improved protection. Scientists will conduct studies to further clarify life histories of species and floristic inventories that improve understanding of species distributions. Recommendations can then be made for fencing and road closures that enhance protection for individual species where appropriate. This can only be accomplished through collaborative efforts among botanic gardens, scientists and public land management agencies.

CASE STUDY
OBJECTIVE 2
TARGET 8

Alpine Conservation Through Seed Studies

Placing seeds in seed banks, below-freezing storage facilities, has become the primary method of *ex-situ* conservation for plants around the world. However, not all seeds are able to survive these dry, subzero conditions. Studies have shown that alpine species are short-lived in seed banks compared to lower elevation species even though they are adapted to extremely cold conditions. Denver Botanic Gardens received an Institute of Museum and Library Services award along with 11 other collaborating institutions for Endangered Exceptional Plant Research led by the Cincinnati Zoo and Botanical Garden. We are researching rare alpine species of Colorado to understand if they can be considered exceptional, requiring a different form of *ex-situ* conservation. This could have a dramatic impact on conservation strategies in the alpine.

Physaria alpina. Photo Alex Seglias

TARGET 7. Conserve 60 percent of threatened alpine plant species in North America *in-situ* by 2030.

Sixty percent of threatened alpine species - those with a G1-G3 rank, will be conserved in areas identified as protected by IUCN protection designations.[25] Botanic gardens will commit to preventing alpine plant species extinction and habitat loss through *in-situ* conservation activities. Botanic garden staff will endeavor to work collaboratively with land agencies to provide technical skills and botanical information.

TARGET 8. Conserve 60 percent of all identified alpine plant species in North America *ex-situ* by 2030.

Sixty percent of identified North American alpine plant species will be maintained in *ex-situ* collections of botanic gardens or seed banks as plants, living tissues or seeds, with appropriate genetic representation to support restoration and will be managed according to science-based protocols.

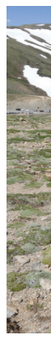
Ex-situ conservation measures such as seed banking, cryopreservation and tissue culture are the most important methods to preserve alpine plant genetic material. Alpine species are particularly vulnerable to climate change and banking seed of these species will allow for studies to understand their ecological tolerance and potential for adaptation, thus informing conservation and restoration programs. This target will require cooperation with public land management agencies as well as private landowners for collection permitting.

It is also important to develop carefully monitored living collections for a better understanding of propagation protocols and ecological requirements. Collections grown as living specimens in botanic gardens can also be valuable for educational purposes and raising public awareness.

Data on all these collections will be shared with the community through tools such as BGCI's *Plant Search* database.[31]

TARGET 9. Ensure that at least 75 percent of all identified threatened North American alpine plant species are held in *ex-situ* collections, and 10 percent are in recovery and/or restoration programs by 2030.

As noted in Target 8, *ex-situ* collections can take the form of plants, living tissues or seeds. Target 9 focuses on securing 75 percent of those with a G1-G3 rank in living and seed bank collections. A higher



Lake Louise, Alberta Canada. Photo Mike Kintgen

Aconitum columbianum.
Photo Nanette Kuich

ex-situ collection target of 90 percent is planned for species with a greater risk of extirpation or extinction based on conservation assessment and threat. Seed banking is considered the highest priority for *ex-situ* conservation.

Ten percent of threatened alpine plants will be placed in recovery and/or restoration programs following protocols such as those developed by the Center for Plant Conservation (CPC).[32] These programs constitute rigorously tested science-based protocols for conservation and *in-situ* re-introduction.

CASE STUDY
OBJECTIVE 1
TARGET 4

Assessing Species Richness Across the Colorado Alpine Ecosystem

Studying species richness in Colorado's alpine.
Photo Mike Kintgen

Denver Botanic Gardens (the Gardens) and Regis University in Denver, Colorado partnered to explore species richness at nine previously understudied sites in the Southern Rockies. The project assessed the role that soil pH and precipitation play in driving species richness in fell fields and dry meadows. The sites ranged from areas with heavy recreational use to those deep within wilderness areas. Herbarium specimens were collected to document species diversity at the sites for the Kathryn Kalmbach Herbarium (KHD) at DBG . There were no previous collections at three of the sites and the other six sites ranged from well to poorly collected. Additionally, a full species list, phenology, and percent coverage of each species were collected.

This study of sites in the Southern Rockies indicates that an increase in both precipitation and soil pH results in an increase in species richness. The pattern runs counter to what was found in the Southern Andes and the Central Alps, where drier areas showed greater species richness. More study sites are needed to confirm the observed pattern. If confirmed this would help predict the best alpine areas to target for *in-situ* protection.

OBJECTIVE 3. Promote awareness of the alpine ecosystem and plant diversity through education and outreach.

TARGET 10. Incorporate the irreplaceable value of the North American alpine ecosystem and plant diversity into educational and public awareness programs at botanic gardens by 2025.

Beartooth Mountains, Montana. Photo Mike Kintgen

Gentiana algida. Photo Nanette Kuich

Communication, education, and the raising of public awareness about the importance of alpine plant diversity are critical for the achievement of all targets of the Alpine Strategy. This target is understood to refer to both informal and formal education at all levels. Target audiences include botanic gardens' board members, staff, docents and volunteers as well as students, the general public, and policy makers. Consideration should be given to developing specific indicators to monitor progress toward overall achievement of the target.

Botanic gardens have an important role in raising public awareness about plant biodiversity loss and its potential effects on the alpine ecosystem. Gardens have been shown to positively influence visitors' environmental attitudes,[33] where they expect to receive accurate, unbiased information. Multiple informational techniques should be used to meet the knowledge, interests and needs of visitors for greatest impact.[34] Visitor conversations with staff and docents is especially important for dispersal of sound scientific information.

It is not enough to just inform visitors about the need for alpine plant conservation[35] and the work being done by botanic gardens in this regard.[36] Supplying pathways to be active in conservation projects is essential.[37] An educated and motivated citizen can discern the accuracy of publicly distributed information and provide valuable personal support to conservation projects and organizations. Education and individual behavior are not sufficient to turn the tide on threats to alpine plant biodiversity and survival, however. Change must also occur at the legislative level. With education, environmental legislation can be proposed and supported by botanic gardens and citizens and, with their pressure, compel conservation actions by their legislators.[38]

Treeline at Izta-Popo National Park, Mexico. Photo Alamy Stock

OBJECTIVE 4. Build capacity for the conservation of alpine plant species and associated habitats.

TARGET 11. Increase the number of trained professionals working on North American alpine plant conservation to address local, regional and national needs by 2030.

Botany is an established science. However, there has been a decline in formal botanical education programs at all levels and in the number of professional government agency botanists, raising concern about the future study and fate of plants.[39] A deficiency of educational programs and interest in botanical studies has led to a general lack of basic botany and plant identification skills in the current generation of scientists.

Botanic gardens must increase educational programs, fieldwork, and research in alpine plants to address the decline in botanical studies and shortage of botanists and horticulturists. These programs and collaborative efforts with universities will contribute to training future botanists and horticulturists whose work will be necessary to stem the growing loss of the world's plants and threats to botanical diversity.

TARGET 12. Establish and strengthen networks, partnerships, associations and stakeholders for alpine conservation activities at regional, national and international levels by 2030.

This Strategy urges botanic gardens to partner with institutions and appropriate stakeholders to strengthen plant conservation activities. Looking after North America's alpine plants and habitats is a shared responsibility of professional and amateur botanists and horticulturists alike. Botanic gardens must take on the responsibility of championing diverse partnerships with governments, public agencies, academic institutions and individuals who all have a role to play in alpine plant conservation.

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DENVER BOTANIC GARDENS

1007 York Street
Denver, CO 80206
www.botanicgardens.org

522 South Frontage Road East
Vail, CO 81657 USA
www.bettyfordalpinegardens.org