ABSTRACT

North America harbors a rich native flora of crop wild relatives—the progenitors and closely related species of domesticated plants—as well as a range of culturally significant wild utilized plants. Despite their current and potential future value, they are rarely prioritized for conservation efforts; thus many species are threatened in their natural habitats, and most are underrepresented in plant genebanks and botanical gardens. Further coordination of efforts among land management, botanical, and agricultural science organizations will improve conservation and general public awareness with regard to these species. We present examples of productive collaborations focused on wild cranberries (Vaccinium macrocarpon and Vaccinium oxycoccos) and chile peppers (Capsicum annuum var. glabriusculum). We then discuss five shared priorities for further action: (1) understand and document North America’s crop wild relatives and wild utilized plants, (2) protect threatened species in their natural habitats, (3) collect and conserve ex situ the diversity of prioritized species, (4) make this diversity accessible and attractive for plant breeding, research, and education, and (5) raise public awareness of their value and the threats to their persistence.

Index terms: crop wild relatives; ex situ conservation; in situ conservation; wild utilized species

INTRODUCTION

North America harbors a rich flora of wild relatives of significant agricultural and horticultural crops, including wild apples (Malus Mill.), beans (Phaseolus L.), blueberries and cranberries (Vaccinium L.), chile peppers (Capsicum L.), corn (Zea L. and Tripsacum L.), cotton (Gossypium L.), grapes (Vitis L.), hops (Humulus L.), onions (Allium L.), pumpkins (Cucurbita L.), sunflowers (Helianthus L.), and many more (Supplementary Table 1; Khoury et al. 2013; Contreras-Toledo et al. 2018; Greene et al. 2018, 2019). The region is also home to a diversity of wild utilized plants still harvested and used by people, such as sugar maple (Acer saccharum Marshall) and wild rice (Zizania palustris L.).

Alongside direct uses for human nutrition and cultural importance (Cruz-Garcia and Price 2014; Gascon et al. 2015; Willis 2017), these plants offer valuable traits for crop breeding, including pest and disease resistance and tolerance to climatic stresses (Hajjar and Hodgkin 2007; Dempewolf et al. 2017). For these reasons, it is worrisome that the natural habitats of many North American crop wild relative and wild utilized plant populations are degraded or disappearing, and most species lack sufficient representation in public genebanks, botanical gardens, and other ex situ repositories (Zhang et al. 2017; Frances et al. 2018; Greene et al. 2018, 2019).

Collaborations among land management, agricultural research, and botanic research and education organizations interested in crop wild relatives and wild utilized plants are providing evidence of the efficacy of combined efforts. We describe two examples of ongoing initiatives in the section below. We then discuss the key elements of five shared priorities for further action, which were recently developed with input...
from a wide range of botanical and agricultural researchers, land management professionals, and educators, both through online surveys and during in-person stakeholder consultations at the World Food Prize Foundation in Des Moines, Iowa, 2–4 April 2019 (Khoury et al. 2019d).

COLLABORATIVE CONSERVATION OF NATIVE CROP WILD RELATIVES

Wild Cranberries (Vaccinium L.)

The US Forest Service (USFS) and the Agricultural Research Service (ARS), two sister agencies within the USDA, have joined forces to conserve crop wild relatives in the United States (Williams and Greene 2018). The USFS-ARS Joint Strategic Framework on the Conservation and Use of Native Crop Wild Relatives in the United States (USFS and ARS 2014) outlines the approaches used by the agencies. Conservation of populations of crop wild relatives occurring in situ on National Forests and Grasslands is linked with ex situ conservation of plants in the ARS genebanks. The agencies, often working with additional collaborators, identify key populations of crop wild relatives on National Forest lands. The USFS then monitors and manages the sites to maintain their long-term sustainability. The ARS collects seeds or plants from the sites and makes them available for use in research, education, and breeding.

The USFS, ARS, and the University of Wisconsin are conducting a pilot project under the Strategic Framework to protect wild populations of the large cranberry (V. macrocarpon Aiton) and a close wild relative, the small cranberry (V. oxycoccos L.) on National Forests throughout the range of the species in the United States. Twenty-one populations of V. macrocarpon and 26 populations of V. oxycoccos are included in the project. Botanists from ARS and the USFS have studied the populations of both species and collected leaf samples, herbarium specimens, and seeds, while geneticists at ARS and the University of Wisconsin have assessed their genetic diversity. Substantial variation was observed across the range of both species, and genetic analysis confirmed the discovery of a wild V. macrocarpon population outside the known range of the species (L. Rodriguez-Bonilla, unpub. data). The ARS plant genebank in Corvallis, Oregon, is maintaining seed from the populations for long-term conservation. Collaborators are working together to select the highest priority sites for further conservation management, using factors including planned USFS land management activities, distance from other populations, sustainability, population size, genetic profile, ease of access, and significance to Native Americans.

Wild Chile Peppers (Capsicum L.)

Following a number of years of research and collaborations involving the USFS, academic partners, and local nonprofits including Native Seeds/SEARCH, the 2836-acre Wild Chile Botanical Area located in the Rock Corral Canyon subwatershed of the Coronado National Forest in southern Arizona was designated. Established in 1999 to protect and to provide opportunities to research the wild progenitor (C. annuum L. var. glabriusculum (Dunal) Heiser & Pickersgill) of the most important chile pepper crop species, the Wild Chile Botanical Area was the first special botanical area in the United States designated for crop wild relative protection.

Important scientific progress has been made through research performed in the Botanical Area over the past two decades. Spatial associations with nurse plants and associated microclimatic differences related to protection from frosts have been clarified (Tewksbury et al. 1999). Feeding studies of the wild chiles with birds and small mammals have contributed to a better understanding of the ecological determinants of pungency (hotness) and their association with host plants and migratory animals, as well as potential disruptions to these interactions due to climate change (Tewksbury and Nabhan 2001; Tewksbury et al. 2008; Carlo et al. 2009; Carlo and Tewksbury 2014). Genetic diversity and potential uniqueness of these northernmost populations of the taxon have also been investigated (Votava et al. 2002).

Involved organizations are currently examining the potential via the Strategic Framework to expand the scope of the Botanical Area to explicitly include other important native crop wild relatives, including wild quinoa (Chenopodium berlandieri Moq.), wild cassava (Manihot angustiloba [Torr.] Mull. Arg. and Manihot daviesiae Croizat), and wild tepary bean (Phaseolus acutifolius A. Gray). Expansion of the Botanical Area scope is also expected to help ensure that the wild chile pepper populations persist while nearby commercially harvested wild populations of the taxon continue to suffer dramatic declines (Gonzalez-Jara et al. 2011).

SHARED PRIORITIES FOR NORTH AMERICAN CROP WILD RELATIVES AND WILD UTILIZED PLANTS

To accomplish the goals of enhanced conservation, facilitated use, and increased public awareness of North America’s crop wild relatives and wild utilized plants, partnerships among plant conservation, land management, agricultural science, and botanical education and outreach organizations are essential. Five shared priorities for further action have been developed by these communities (published in full in Khoury et al. 2019d). Essential details are shared below.

1. Understand and document North America’s crop wild relatives and wild utilized plants, assess threats to their natural habitats, and determine gaps in their conservation

Species inventories and conservation assessments have been generated for various taxa and for some geographic regions in North America (e.g., Wiersema et al. 2012; Khoury et al. 2013, 2015, 2019b, 2019c; Castañeda-Alvarez et al. 2015; Kantar et al. 2015; Contreras-Toledo et al. 2018; Greene et al. 2019), but many land management areas have no comprehensive species lists, and for many species, assessments are either out of date or have not yet been performed (Frances et al. 2018).

Assessments are needed to further document and define the highest-priority species across North America, understand spatial patterns with regard to their genetic diversity, analyze threats to populations, and identify the most important gaps in conservation. Results should be integrated into relevant information platforms used by the conservation, land management, genetic resource, and agricultural research communities
(e.g., BGCI 2019; CONABIO 2019; NatureServe 2019; USDA ARS NPGS 2019; USDA USFS NRM 2019). Increased alignment of these platforms is recommended to support seamless sharing of information and priorities with professionals in these communities, as well as with the public.

2. Protect North America’s crop wild relatives and wild utilized plants in their natural habitats

North America’s public, private, military, Native American, and other open spaces conserve numerous crop wild relative and wild utilized plant populations collaterally, because of overall land protection practices. These plants are not explicitly prioritized except in a few exceptional cases, e.g., for the wild chile pepper and cranberry examples listed above, as well as for a few populations of wild maize in central Mexico (De La Torre et al. 2018). Most species are not currently sufficiently conserved in their natural habitats (Khoury et al. 2019a).

Conservation sites covering populations of the highest priority and/or most threatened crop wild relatives and wild utilized plants need to be designated in existing protected areas, and additional protected areas might need to be considered, to adequately protect the genetic diversity of these plants in their natural habitats to support continued evolution. Conservation of priority species that occurs collaterally within multiple land use areas should be upgraded to active management with the aim of ensuring the viability of populations for the long term, including under the pressures of climate change. To do so, priorities for species conservation will need to be expanded beyond those few currently officially listed as threatened and endangered.

3. Collect and conserve North America’s prioritized crop wild relatives and wild utilized plants in ex situ collections

Ex situ collections of important crop wild relatives and wild utilized plants are maintained in public genebanks and botanical gardens across North America, but these collections are not currently complete with regard to coverage of taxa, nor of genetic diversity within species (Castañeda-Alvarez et al. 2016; Greene et al. 2018, 2019; Khoury et al. 2019a). Prioritized crop wild relatives and wild utilized plants across North America need further collecting for ex situ conservation. Further research is needed to develop techniques for the maintenance of species that currently require expensive, nonstandard approaches.

4. Make North America’s crop wild relatives and wild utilized plants accessible and attractive to plant breeders, researchers, and educators

North America’s public genebanks, botanical gardens, and open spaces provide the foundation for making crop wild relatives and wild utilized plants accessible for research and education. These plants need to be carefully managed to ensure that adequate, high quality, true to type propagules are available for distribution, and they need to be easily accessible via online databases. Indigenous, traditional, and local knowledge about these plants must be valued and protected through access provided by agreements based on mutually agreed terms. These plants should also be accessible to the public through botanic garden displays and through information initiatives on public lands.

5. Raise public awareness about North America’s crop wild relatives and wild utilized plants

Creating coordinated educational and communications programs to help raise awareness and provide a backdrop for support of crop wild relative and wild utilized plant conservation is necessary to the long-term viability of conservation and plant breeding efforts. Skilled education and outreach professionals should lead collaborative efforts to raise awareness about the importance of, and threats to, North American crop wild relatives and wild utilized plants.

These five priorities are interdependent and require coordinated action. Current initiatives that combine the efforts of land managers, agricultural researchers, botanic gardens, and other organizations for the conservation and use of wild cranberries and wild chile peppers are demonstrating the value of collaborative approaches. Through partnerships, significant further progress can be made in conservation, use, and public engagement around North American crop wild relatives and wild utilized plants.

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