Conservation Gap Analysis of Native U.S. Oaks

Species profile: ***Quercus havardii***

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SPECIES OF CONSERVATION CONCERN

CALIFORNIA

Channel Island endemics:
Quercus pacifica, Quercus tomentella

Southern region:
Quercus cedrosensis, Quercus dumosa, Quercus engelmannii

Northern region and / or broad distribution:
Quercus lobata, Quercus parvula, Quercus sadleriana

SOUTHWESTERN U.S.

Texas limited-range endemics
Quercus carmenensis, Quercus graciliformis, Quercus hinckleyi, Quercus robusta, Quercus tardifolia

Concentrated in Arizona:
Quercus ajoensis, Quercus palmeri, Quercus toumeyi

Broad distribution:
Quercus havardii, *Quercus laceyi*

SOUTHEASTERN U.S.

State endemics:
Quercus acerifolia, Quercus boyntonii

Concentrated in Florida:
Quercus chapmanii, Quercus inopina, Quercus pumila

Broad distribution:
Quercus arkansana, Quercus austrina, Quercus georgiana, Quercus oglethorpensis, Quercus similis

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Quercus havardii Rydb.

Synonyms: N/A **Common Names:** Harvard oak, Shinnery oak

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DISTRIBUTION AND ECOLOGY

Quercus havardii, or Harvard oak, occurs in the southwestern U.S., including sites in southeastern New Mexico, northern and western Texas, western Oklahoma, as well as a disjunct series of populations in northern Arizona, southern Utah and minimally in Colorado and northern New Mexico. Harvard oak historically occupied five to seven million acres of the Southern Great Plains: one million acres in Oklahoma, 1.5 million acres in New Mexico, and 3.5 million acres in Texas.[1] This small oak defines Sand Shinnery communities and is the major shrub species compromising plains-mesa sand scrub vegetation in southeastern New Mexico; it thrives in deep sandy soils, including sand dunes.[2] Harvard oak occurs primarily underground, with only one-tenth of the plant (0.6 to 0.8 meters) above ground and roots extending five to six meters below ground. This extensive underground network is vital to the health of the ecological community, due to its stabilizing effects on sand.[3]

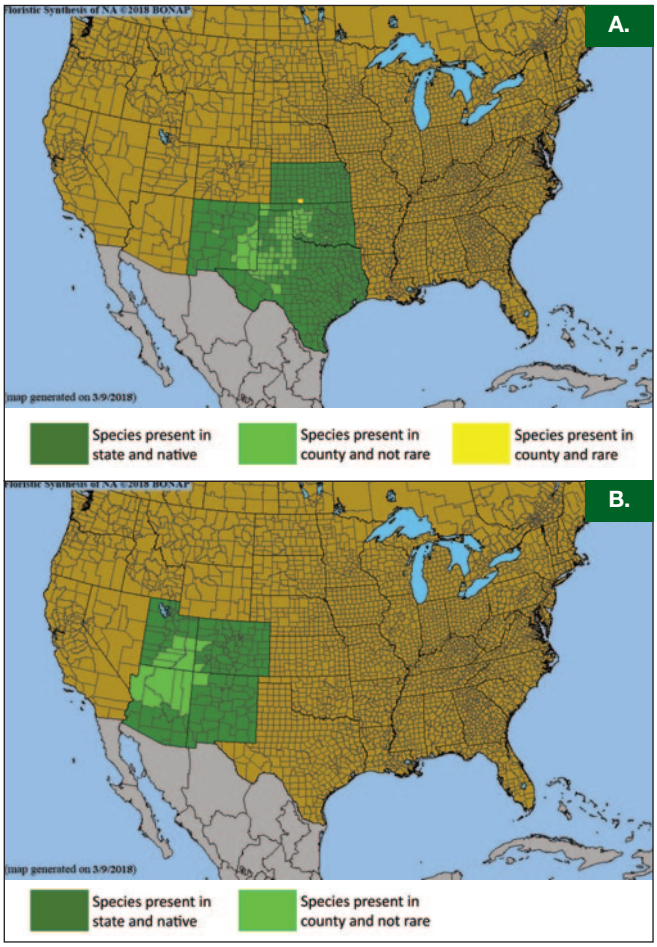

Figure 1. County-level distribution map for **A)** *Quercus havardii* and **B)** *Quercus welshii*. Source: Biota of North America Program (BONAP).[8]

Across its distribution, *Q. havardii* is generally classified as a single species. However, segregation of its disjunct western distribution (*Q. havardii* var. *tuckeri*) as a separate species has been proposed by several authors who label it *Q. welshii*.[4,5,6] Preliminary work focused on oaks of the Four Corners region suggests that *Q. havardii* is distinct in that area, and additional work is underway to address this question at the full range level (S. Hoban & R. McCauley pers. comm., 2017).[7] Without further evidence of species segregation and the similarity in ecological functioning, for the purpose of this report *Q. havardii* is recognized in its broad interpretation as one species with a disjunct distribution.

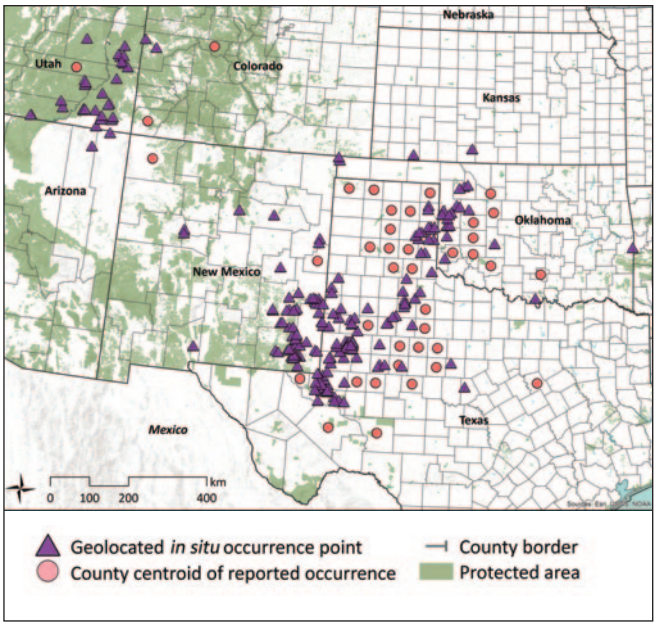

Figure 2. Documented *in situ* occurrence points for *Quercus havardii*. Protected areas layer from U.S. Geological Survey Gap Analysis Program (GAP) 2016 Protected Areas Database of the U.S. (PAD-US).[9]

VULNERABILITY OF WILD POPULATIONS

Table 1. Scoring matrix identifying the most severe demographic issues affecting *Quercus havardii*. Cells are highlighted when the species meets the respective vulnerability threshold for each demographic indicator. Average vulnerability score is calculated using only those demographic indicators with sufficient data (i.e., excluding unknown indicators).

Demographic indicators	Level of vulnerability						
	Emergency Score = 40	**High** Score = 20	**Moderate** Score = 10	**Low** Score = 5	**None** Score = 0	**Unknown** No score	**Score**
Population size	< 50	< 250	< 2,500	< 10,000	> 10,000	Unknown	0
Range/endemism	Extremely small range or 1 location	EOO < 100 km² or AOO < 10 km² or 2-4 locations	EOO < 5,000 km² or AOO < 500 km² or 5-9 locations	EOO < 20,000 km² or AOO < 2,000 km² or 10+ locations	EOO > 20,000 km² or AOO > 2,000 km²	Unknown	0
Population decline	Extreme	>= 80% decline	>= 50% decline	>= 30% decline	None	Unknown	10
Fragmentation	Severe fragmentation	Isolated populations	Somewhat isolated populations	Relatively connected populations	Connected populations	Unknown	10
Regeneration/ recruitment	No regeneration or recruitment	Decline of >50% predicted in next generation	Insufficient to maintain current population size	Sufficient to maintain current population size	Sufficient to increase population size	Unknown	10
Genetic variation/ integrity	Extremely low	Low	Medium	High	Very high	Unknown	5
						Average vulnerability score	5.8
						Rank relative to all U.S. oak species of concern (out of 19)	14

THREATS TO WILD POPULATIONS

High Impact Threats

Human use of landscape — agriculture, silviculture, ranching, and/or grazing: Agriculture has resulted in extensive habitat alteration within *Q. havardii* communities, including soil compaction, decreased stability of microclimates, introduction of invasive plants, loss of habitat, extractive use of groundwater, and fragmentation of the ecosystem.[10]

Climate change — habitat shifting, drought, temperature extremes, and/or flooding: *Quercus havardii* inhabits areas that are highly arid, and it is unknown whether the species can adapt to projected increases of aridity. The western portion of the range is projected to dry which may lead to major changes in distribution and abundance of *Q. havardii* (R. McCauley pers. comm., 2018). It already seems as though conditions are too dry to allow for successful regeneration (S. Hoban pers. comm., 2018).

Moderate Impact Threats

Human use of landscape — residential/commercial development, mining, and/or roads: Habitat loss and fragmentation of Sand Shinnery communities is a concern due to dramatically expanding roads and pipelines for oil and gas development. This is exacerbated by the fragility of *Q. havardii* habitat. Since fragmentation destabilizes sand dunes.[10] Once Havard oak is removed from a location, its recolonization is slow, though it can show vigorous resprouting if some plants do remain (S. Hoban pers. comm., 2018).

Human use of landscape — tourism and/or recreation: Damage from off-road vehicles has been observed in multiple locations, though the extent of damage throughout the species range is not currently known (S. Hoban pers. comm., 2018).

Human modification of natural systems — disturbance regime modification, pollution, and/or eradication: *Quercus havardii* is poisonous to livestock during the spring and competes with grass and forbs for water and nutrients; this is often detrimental to ranching operations. Herbicides such as Tebuthiuron are used to eradicate Harvard oak. In 1998 it was reported that 100,000 acres of Harvard oak habitat were targeted for treatment in New Mexico, and 320,000 in Texas. These are likely underestimates, since most of Harvard oak exists on private land.[1]

Low Impact Threats

Genetic material loss — inbreeding and/or introgression: Introgression of *Q. havardii* with other oaks has been observed in multiple locations. Suspected hybrid populations occur with *Q. gambelii* and *Q. turbinella* in Harvard oak's western range, and with *Q. stellata* in the East, (R. McCauley pers. comm., 2018). Genetic analyses show that the species has moderate to moderate-low levels of heterozygosity overall. Some populations may also be moderately or highly inbred, potentially impeding future reproduction. The species does occur across a very wide environmental gradient, which suggests that there may be enough genetic variation for adaptation. Some populations remain quite large, with hundreds of individuals (S. Hoban pers. comm., 2018).

CONSERVATION ACTIVITIES

In 2017 *Quercus* accessions data were requested from *ex situ* collections. A total of 162 institutions from 26 countries submitted data for native U.S. oaks (Figures 3 and 4). Past, present, and planned conservation activities for U.S. oak species of concern were also examined through literature review, expert consultation, and conduction of a questionnaire. Questionnaire respondents totaled 328 individuals from 252 organizations, including 78 institutions reporting on species of concern (Figure 6).

Results of 2017 *ex situ* survey	
Number of *ex situ* collections reporting this species:	12
Number of plants in *ex situ* collections:	417
Average number of plants per institution:	35
Percent of *ex situ* plants of wild origin:	98%
Percent of wild origin plants with known locality:	93%

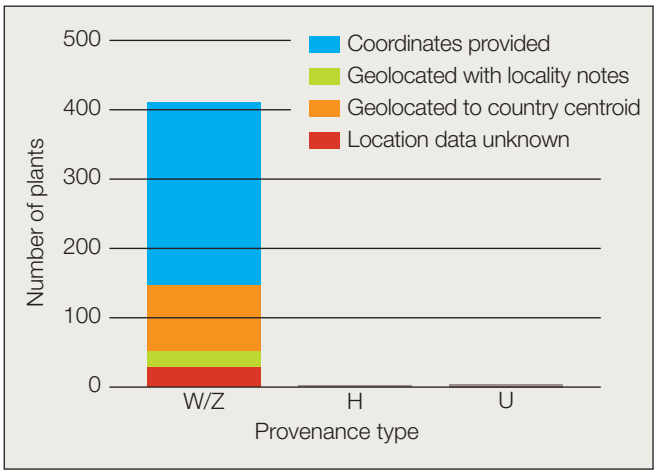

Figure 3. Number and origin of *Quercus havardii* plants in *ex situ* collections. Provenance types: W = wild; Z = indirect wild; H = horticultural; U = unknown.

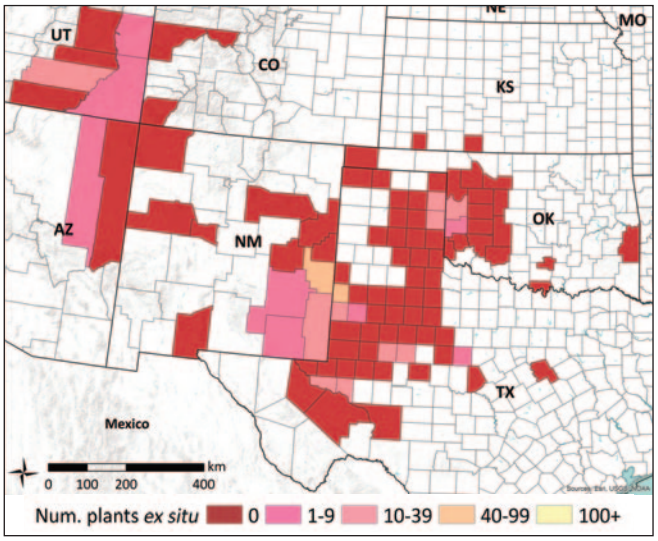

Figure 4. *Quercus havardii* counties of *in situ* occurrence, reflecting the number of plants from each county in *ex situ* collections.

A spatial analysis was conducted to estimate the geographic and ecological coverage of *ex situ* collections (Figure 5). Fifty-kilometer buffers were placed around each *in situ* occurrence point and the source locality of each plant living in *ex situ* collections. Collectively, the *in situ* buffer area serves as the inferred native range of the species, or "combined area *in situ*" (CAI50). The *ex situ* buffer area represents the native range "captured" in *ex situ* collections, or "combined area *ex situ*" (CAE50). Geographic coverage of *ex situ* collections was estimated by dividing CAI50 by CAE50. Ecological coverage was estimated by dividing the number of EPA Level IV Ecoregions present in CAE50 by the number of ecoregions in CAI50.

Estimated *ex situ* representation	
Geographic coverage:	26%
Ecological coverage:	39%

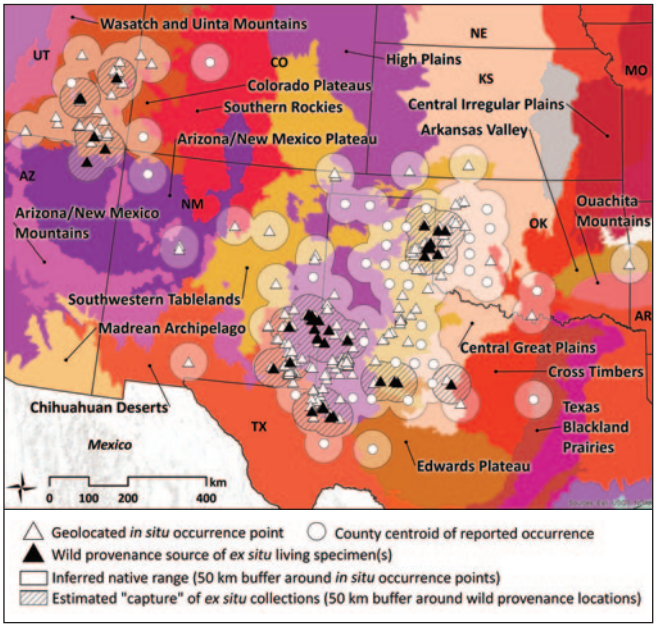

Figure 5. *Quercus havardii in situ* occurrence points and *ex situ* collection source localities. U.S. EPA Level III Ecoregions are colored and labelled.[11] County centroid is shown if no precise locality data exist for that county of occurrence. Email treeconservation@mortonarb.org for information regarding specific coordinates.

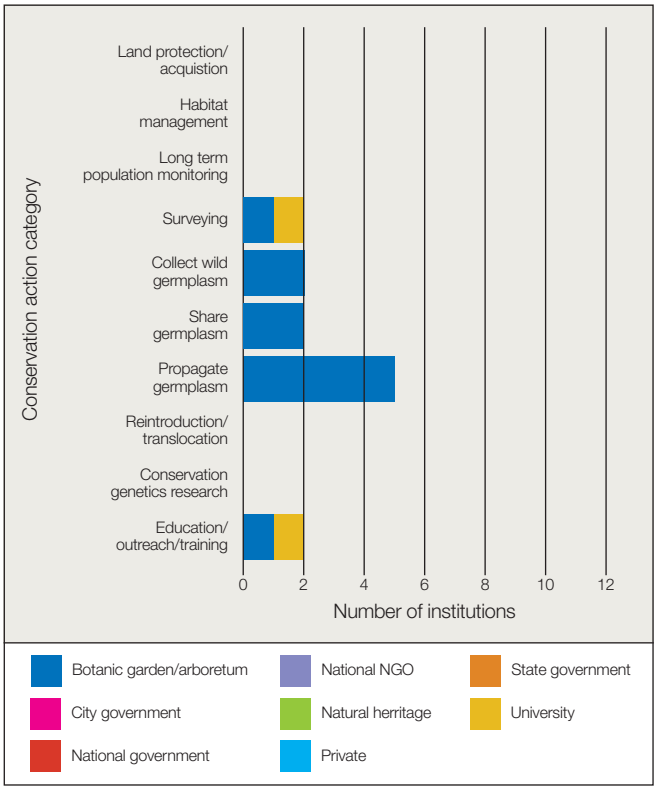

Figure 6. Number of institutions reporting conservation activities for *Quercus havardii* grouped by organization type. Seven of 252 institutions reported activities focused on *Q. havardii* (see Appendix D for a list of all responding institutions).

Land protection: Within the inferred native range of *Q. havardii*, 30% of the land is covered by protected areas (Figure 7). Most of Harvard oak habitat in the eastern half of its range is on private lands, while much of the land in its western distribution is protected.

In the eastern portion of Harvard oak's range where most land is private, there are still a few noteworthy protected areas harboring the species. These include Black Kettle National Grassland (13,000 acres) and Packsaddle Wildlife Management Area (16,000 acres) in Oklahoma, as well as some areas in New Mexico. At the end of the 20th century New Mexico was estimated to have 1,200,000 acres of *Q. havardii* habitat managed by Bureau of Land Management (BLM), 500,000 acres covered by state trusts, and 21,000 acres managed by the New Mexico Department of Game and Fish.[1]

The majority of Harvard oak's western distribution is located on BLM or Navajo Nation lands. Additional populations occur on U.S. government lands including Arches National Park, Canyonlands National Park, Grand Staircase-Escalante National Monument, and Bears Ears National Monument. Close to 100% of the range in the West is on protected or public land. Some of these lands may be subject to disturbance from natural resource extraction, but this is likely minimal. Navajo Nation lands support most of the western *Q. havardii* populations, where land use is quite stable (S. Hoban & R. McCauley pers. comm., 2018).

Sustainable management of land: Some *Q. havardii* habitat is undergoing successful land management, as exemplified by the Lesser Prairie Chicken, a rare bird relying upon an ecosystem stabilized by Harvard oak. "In 2014, the Lesser Prairie Chicken was listed as Threatened under the Endangered Species Act; however, in 2016 a Texas judge ruled that this designation had been errant because voluntary conservation efforts had not been taken into account during the initial decision. Although some activists are against this decision, others believe it validates the work of public-private conservation partnerships in protecting the species."[12] Another at-risk wildlife species, the 'Mescalero Sands' White-tailed deer, is likely increasing the appropriate management of *Q. havardii* habitat, as "multiple land management agencies, conservation organizations and landowners are now coordinating a plan to balance the needs of the ecosystem with human use of the land."[13]

Population monitoring and/or occurrence surveys: Two institutions reported this activity in the conservation action questionnaire, but no other details are currently known.

Wild collecting and/or *ex situ* curation: With funding from a 2016 APGA-USFS Tree Gene Conservation Program grant, Sean Hoban of The Morton Arboretum drove 2,000 miles across the western U.S. to visit 36 populations of Harvard oak and collect 1,700 acorns, which were then distributed to ten institutions across the country. Partner institutions for the collecting expedition included Fort Lewis College Herbarium, Texas Arboretum & LBJ Wildflower Center, Trees That Please Nursery, University of Colorado, and Texas Tech University. Although germination rates were high from this collection, seedling mortality was also high in greenhouse containers at several institutions, with unknown cause (S. Hoban pers. comm., 2018).[14,15]

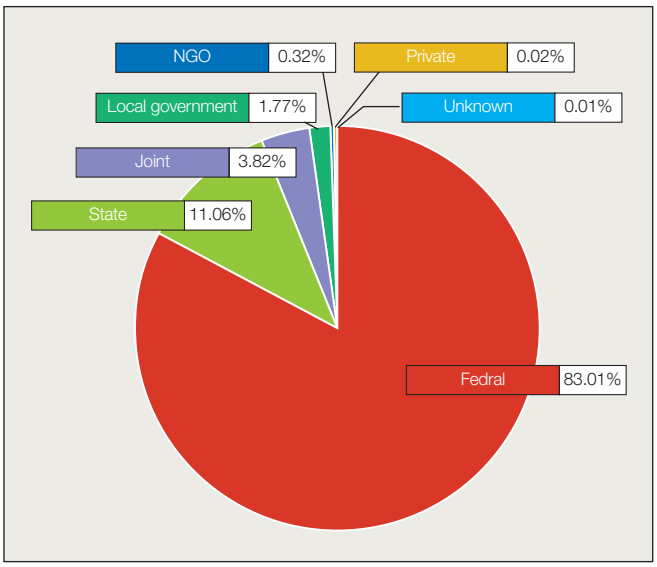

Figure 7. Management type of protected areas within the inferred native range of *Quercus havardii*. Protected areas data from the U.S. Geological Survey Gap Analysis Program (GAP) 2016 Protected Areas Database of the U.S. (PAD-US).[9]


Sean Hoban

Propagation and/or breeding programs: With funding from the APGA-USFS Tree Gene Conservation Program, The Morton Arboretum and partner institutes have been propagating *Q. havardii* for placement of these specimens among their living collections. Before this conservation collection trip, Harvard oak was only present in one public garden (S. Hoban pers. comm., 2017).[14,15]

Reintroduction, reinforcement, and/or translocation: No known initiatives at the time of publication.

Research: Davis (2013) found that current *Q. havardii* habitat restoration techniques are not sufficient, including activities such as removing oilfield infrastructure with the hope that the species will repopulate the area. The study proposes the use of Harvard oak rhizomes as a propagation source in the reestablishment of the species within disturbed areas, and found some success within trials. This is a technique that must be further researched, and could then be applied to areas of historic *Q. havardii* range that have been altered by ranchers and oilfields.[10] Hoban, McCauley, and colleagues are currently researching conservation genetic concerns for this species (S. Hoban pers. comm., 2018).

Education, outreach, and/or training: The *Q. havardii* ecosystem has gathered attention due to its unique wildlife, including the Dunes sagebrush lizard (Sceloporus arenicolus), which is only found in Harvard oak habitat and is listed as Vulnerable on the IUCN Red List.[16] The Lesser Prairie Chicken and 'Mescalero Sands' White-tailed deer have also received public attention.[17] With funding from the APGA-USFS Tree Gene Conservation Program in 2016, wild-collected *Q. havardii* acorns were placed in propagation, with the intention of display for public education (S. Hoban pers. comm., 2017).

Species protection policies: No known initiatives at the time of publication.

PRIORITY CONSERVATION ACTIONS

Harvard Oak continues to be threatened by expanding agriculture and natural gas development, increasing aridity, lowering of the water table, and off-road vehicle use. Though, increased public recognition of this species' role in the ecosystem is a positive sign. Further actions should include continued outreach to the public regarding the importance of these communities, to encourage greater stewardship and consideration in development plans. Signage could be helpful in locations of high off-road vehicle use. Across the species range, conservation of lands is much greater in the West, therefore efforts should focus on Harvard oak communities in the eastern portion.

In addition to continued conservation of current communities, reintroduction and assisted migration should be considered. Range shifts caused by a changing climate are real for this species particularly due to changes in rainfall patterns. Initially, work should aim to generate predictive niche models in light of varying climate change scenarios. Using these models, Shinnery communities with the greatest chance to survive changes should be prioritized for restoration. Later, localities currently marginal for Shinnery communities but which show good potential for persistence in the future can be identified, and individuals with suitable genotypes could be introduced. In the western part of the range and on range edges in the East, very small and isolated populations could benefit from reinforcement. Reintroduction and assisted migration activities will also hinge on developing an understanding of Harvard oak's reproductive system, including information on seed viability, seedling survival rates under different conditions, and rhizome propagation.

The 2016 seed collection, supported by the APGA-USFS Tree Gene Conservation Partnership and lead by The Morton Arboretum, has increased the number of institutions safeguarding *Q. havardii* in *ex situ* collections. However, several institutions lost a high percentage of seedlings. Research may be needed into appropriate greenhouse care and long-term care of the species in a garden, especially in locations outside its natural range. Seed from the western part of the range was much less abundant, and therefore future seed collections may be needed from the western range. Finally, monitoring will be useful in small populations to confirm their stability.

Conservation recommendations for *Quercus havardii*

Highest Priority
- Education, outreach, and/or training
- Land protection
- Research (climate change modeling; reproductive biology/ regeneration; restoration protocols/guidelines; taxonomy/phylogenetics)

Recommended
- Population monitoring and/or occurrence surveys
- Reintroduction, reinforcement, and/or translocation
- Sustainable management of land
- Wild collecting and/or *ex situ* curation

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