Recovery Plan for *Manihot walkerae* (Walker's manioc)
https://esadocs.cci-dev.org/ESAdocs/recovery_plan/931212.pdf

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DRAFT AMENDMENT 1

We have identified the best available information that indicates the need to amend recovery criteria for *Manihot walkerae* (Walker's manioc) since the recovery plan was completed in 1993. In this proposed modification, we synthesize the adequacy of the existing recovery criteria, present amended recovery criteria, and the rationale supporting the proposed recovery plan modification. The proposed modifications are shown as an addendum that supplements the recovery plan, superseding only Executive Summary (p. ii) and Objective and Criteria in Part II – Recovery (pp. 16–17) of the recovery plan.

For
U.S. Fish and Wildlife Service
Southwest Region
Albuquerque, New Mexico

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BACKGROUND INFORMATION

Recovery plans should be consulted frequently, used to initiate recovery activities, and updated as needed. A review of the recovery plan and its implementation may show that the plan is out of date or its usefulness is limited, and therefore warrants modification. Keeping recovery plans current ensures that the species benefits through timely, partner-coordinated implementation based on the best available information. The need for, and extent of, plan modifications will vary considerably among plans. Maintaining a useful and current recovery plan depends on the scope and complexity of the initial plan, the structure of the document, and the involvement of stakeholders.

An amendment involves a substantial rewrite of a portion of a recovery plan that changes any of the statutory elements. The need for an amendment may be triggered when, among other possibilities: (1) the current recovery plan is out of compliance with regard to statutory requirements; (2) new information has been identified, such as population-level threats to the species or previously unknown life history traits, that necessitates new or refined recovery actions and/or criteria; or (3) the current recovery plan is not achieving its objectives. The amendment replaces only that specific portion of the recovery plan, supplementing the existing recovery plan, but not completely replacing it. An amendment may be most appropriate if significant plan improvements are needed, but resources are too scarce to accomplish a full recovery plan revision in a short time.

Although it would be inappropriate for an amendment to include changes in the recovery program that contradict the approved recovery plan, it could incorporate study findings that enhance the scientific basis of the plan, or that reduce uncertainties as to the life history, threats, or species' response to management. An amendment could serve a critical function while awaiting a revised recovery plan by: (1) refining and/or prioritizing recovery actions that need to be emphasized, (2) refining recovery criteria, or (3) adding a species to a multispecies or ecosystem plan. An amendment can, therefore, efficiently balance resources spent on modifying a plan against those spent on managing implementation of ongoing recovery actions.

METHODOLOGY USED TO COMPLETE THE RECOVERY PLAN AMENDMENT

In 2009, the U.S. Fish and Wildlife Service (Service) produced the Walker's manioc Five-Year Status Review (hereafter, 5-year review) (Service 2009, entire). The 5-year review was used as a principal reference for this draft recovery plan amendment because it is the most recent and comprehensive analysis of all information known about this species through 2009. To determine if new information had become available since completion of the 5-year review, inquiries were made to other persons knowledgeable about the species biology and ecology, habitats, and/or potential threats and stressors that might be affecting this species. These individuals included Service staff (National Wildlife Refuge Program) and external partners with information requested including monitoring, research projects, botanical garden seed storage or germination, habitat restoration or other efforts that may have been undertaken since 2009. Additionally, reviews were undertaken of Service files and online searches for journal articles and other information that has become available since 2009.

In addition to information review, the Service relied on the South Texas Plant Recovery Team (STPRT) for assistance in modifying recovery criteria for the Walker's manioc. The STPRT was formed in 2010 (after completion of the 5-year review) to oversee the recovery of nine species of listed plants in South Texas, including Walker's manioc. On June 12 and13, 2018, the STPRT met at Santa Ana National Wildlife Refuge to develop proposed recovery criteria revisions for the Walker's manioc and two other listed plant species. Seven team members attended, including two private citizen botanists, three academic botanists, a Texas Parks and Wildlife Department (TPWD) botanist, and a Service refuge plant ecologist. Nine other Service employees were also in attendance, including the liaison to the recovery team (the Service's Texas State Botanist), the species lead for the three plants, and National Wildlife Refuge and Ecological Services Program staff. The process relied upon open discussion among all members, led by the species' lead and the Texas State Botanist; discussions were guided by an agenda with stated objectives. Additional information was provided to team members including maps that showed known population and metapopulation locations, and handouts of species information, existing criteria, and Endangered Species Act definitions. Following the meeting, Service biologists corresponded with all team members (including members who were unable to attend the meeting in person) via email to solicit review and comments on meeting notes and tables displaying existing versus proposed criteria (South Texas Plant Recovery Team 2018, unpaginated). Through this process of face-to-face meeting and discussions, followed by email reviews and input, the team reached agreement on portions of the proposed recovery criteria amendments for Walker's manioc. By using the STPRT's assistance, the Service was able to inform the State, non-governmental organizations, and members of the private sector about the

proposal to revise recovery criteria as well as to involve experts from these stakeholder groups in the actual modification process.

The proposed recovery criteria amendments will require formal peer review due to the modification of the original down-listing criteria and the establishment of new delisting criteria where none had existed in the original recovery plan. The Service will solicit peer review from at least three independent scientific reviewers with expertise in the species' biology, ecology, and conservation of South Texas native plants and landscapes, including management of invasive species. Peer review will be solicited at the time that the notice of availability of this revision publishes in the *Federal Register*.

ADEQUACY OF RECOVERY CRITERIA

Section 4(f)(1)(B)(ii) of the Endangered Species Act (Act) requires that each recovery plan shall incorporate, to the maximum extent practicable, "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list." Legal challenges to recovery plans (see Fund for Animals v. Babbitt, 903 F. Supp. 96 (D.D.C. 1995)) and a Government Accountability Audit (GAO 2006) also have affirmed the need to frame recovery criteria in terms of threats assessed under the five threat factors (ESA 4(a)(1)).

Recovery Criteria

The Walker's manioc original recovery plan defined criteria for reclassification to threatened, but did not include criteria for delisting the species. The primary recovery objective for the species was maintenance of adequate populations in natural habitat to ensure that the species was safe from extinction. The plan indicated that the restricted distribution of the species and the limited understanding of its life history and habitat requirements meant that it was not possible to predict what measures would be sufficient to allow delisting of the species. The plan stated that accomplishing the tasks in the recovery plan should provide information needed to determine if delisting was possible and what the delisting objectives and criteria should be.

Synthesis

For this recovery criteria revision, certain aspects of Walker's manioc life history and ecology, clarified by ecological monitoring conducted after 1993, were useful in refining downlisting criteria as well as developing criteria to delist the species. For the purpose of this document, the use of the term "site" is defined as a fairly precise geographic location where one or more individuals of the species is found. A "population" may consist of one or many sites among which gene flow, such as pollination or seed dispersal, may occur (Service 2009, p. 4).

The 2009 5-year review concluded that we have a much better understanding of Walker's manioc's physical requirements, such as geological substrate and soil, associated species and habitat, life history, and geographic range (Service 2009, entire). The 5-year review documented an expanded geographic range (distribution) and number of sites for the Walker's manioc compared to what was described in the 1993 recovery plan.

In the U.S., site location data from the Texas Natural Diversity Database (TXNDD; 2007) plus two additional Texas locations reported by a Texas Department of Transportation (TXDOT) contractor in 2009 (TRC 2009, p. ii), brings the total potentially extant sites in the U.S. to 11. In

Mexico, Pronatura Noreste, a Mexican non-governmental organization, verified 24 individual sites in Tamaulipas (Contreras Arquieta 2005, p. 2). Seventeen of the 24 sites occurred in the Loreto Sand Plain in such close proximity to one another that they likely do not constitute separate populations by NatureServe standards but are instead one metapopulation (NatureServe 2004, unpaginated; D. Price 2007, pers. comm.). The total potential extant sites in the U.S. (11) and Mexico (24) is 35.

The largest number of plants at one site was reported from the 17 subpopulations that constitute the Loreto Sand Plains metapopulation (Contreras Arquieta 2005, p. 8 and p. 37). In the Texas sites, the number of plants at any given site has ranged from one individual to approximately 90. Typically, large numbers of manioc plants do not occur at any one site but instead individual plants and patches of plants can occur in a scattered fashion. This is further complicated by the ephemeral nature of aboveground plant material which makes survey results highly variable.

Walker's manioc has been documented from as far north as Duval County in southern Texas (TXNDD 2018, p. 18) to the vicinity of Aldama (Service 2009, p. 11) in the most southern part of the state of Tamaulipas, Mexico; a distance of approximately 532 kilometers (km). In Texas, the distance between the Duval County population and the next closest population (in Starr County) is approximately 137 km. There is potential for the presence of yet undiscovered populations between Duval and Starr counties because appropriate soils, geology, and associated plant communities exist in some places. Survey data are lacking over this geographic span because all land, outside of highway rights-of-way (ROW), is privately owned and not readily accessed.

With the exception of the Duval County population, all known Texas manioc populations occur in western Hidalgo County and southeastern-to-southcentral Starr County with the majority of these populations located within 2.4 km of the Rio Grande. Although the population data show a patchy, scattered distribution, much of the potential habitat between known populations has not been surveyed. The discovery of additional sites in 2009 illustrate the likelihood of finding more populations in unsurveyed suitable habitat on which the land cover has not been mined or otherwise built over.

The Mexican populations outside of the Rancho Loreto metapopulation are scattered, with longer distances in-between than those found in Texas. The large geographic gaps between the species' occurrence in Mexico may be, at least in part, an artifact of surveys being limited to areas where permitted by private landowners. This pattern of occurrence could also be due to habitat loss from conversion of Tamaulipan thornscrub and grasslands to agricultural land uses and caliche mining for road construction.

Life History as it relates to recovery:
Walker's manioc is a geoendemic, found on shallow calcareous soils (30 cm deep) over caliche (Service 2009, p. 12 ; STPRT 2018, entire). All known Walker's manioc populations are associated with calcareous soils underlain by the Goliad geological formation that occurs in a broad swath along an ancient coastline paralleling the modern Gulf of Mexico (Bureau of Economic Geology 1975-1976 in Service 2009, p. 13). Walker's manioc is capable of maintaining itself as a perennial through both seed (sexual reproduction) and by growing

underground tubers that produce aboveground growth. The level of genetic diversity within or between Walker's manioc populations, or subpopulations belonging to metapopulations, has not been investigated.

The results of propagation efforts showed the species to be self-fertile without a specialized pollinator (Best 2008 in Service 2009, p. 10). The species appears to spread at least short distances (several meters) from parent plants through several seed dispersal mechanisms, including spontaneous explosive rupture of seed capsules and myrmecochory (i.e., seed movement via ants) (Best 2008 in Service 2009, p. 10). Although there is a possibility for seed dispersal over longer distances via sheet flow of water, there are no reports to document this mechanism. Distances required for pollinator movements to effectively spread genetic material are unknown. The presence of one individual plant found at a distance of approximately 1.2 km from other known plants on the La Puerta tract of the Lower Rio Grande Valley National Wildlife Refuge (LRGV NWR) (K. Wahl-Villareal 2015, pers. comm) may be evidence of dispersal via methods besides seed capsule dehiscence or myrmecochory.

Walker's manioc is capable of dormancy due to its underground tubers that remain viable even when unfavorable aboveground conditions (e.g., drought, extended period of high temperatures, freezes) result in leaves and stems dying back. The ability of the species to regenerate, or to spread to new sites, via pieces of tuber has positive implications for propagation and reintroduction recovery actions. Observations at LRGV NWR show that manioc plants can begin tuber production at less than one year of age (Best 2008 in Service 2009, p. 10) and that potted manioc plants can produce numerous, large tubers by 2.5 years.

Field observations indicate that javelina (*Pecari tajacu*) dig up and consume tubers, but may also act as agents of dispersal by dropping tuber pieces as they move (Service 2009, p. 18). In Tamaulipas, Mexico, manioc grew from tuber pieces scattered about in a crop field (Best 2008 in Service 2009, p. 16). Tubers appear to help the species survive adverse environmental conditions as well as anthropogenic surface impacts including herbicides, mowing, and perhaps disking or plowing. Manioc has reemerged following herbicide application that killed the above-ground portions of the plants (Best 2008 and Patterson 2008 pers comm. in Service 2009, p. 10).

Recruitment success is unknown for Walker's manioc. Observations of seedlings at a number of sites (TXNDD 2018, p. 18; STPRT 2018, unpaginated; TRC 2009, p. 3-15) provided evidence of successful sexual reproduction in the wild; however, seedling survival may be lower during unfavorable weather conditions. The length of time that seeds remain viable is unknown, but seeds do not appear to persist long on the surface in natural settings (STPRT 2018, unpaginated). At LRGV NWR plant nursery facilities, manioc seeds could remain dormant for up to a year or more, but some seeds could also germinate under ambient conditions in the soil within nine months (Best 2008 in Service 2009, p. 10).

Level of Protection

Three of the largest Texas populations occur on protected tracts of the LRGV NWR (TXNDD 2018, pp. 6, 8, and 10; Best 1996 in Service 2009), which implements monitoring and management actions intermittently. All other populations in Texas and Mexico, except for a

small site on TXDOT ROW, are on privately-owned land. The TXDOT site in Hidalgo County is considered highly vulnerable because of its location along a road (D. Price 2007, pers. comm.).

Over the entire binational range of the species, three private landowners have indicated willingness to take actions to protect and conserve the plant by signing voluntary conservation agreements. Of these three, two are in Tamaulipas; one is Rancho Loreto, the site of the large metatpopulation, and the other Ejido Vicente Guerrero (a multi-landowner organization), both of whom have signed agreements with Pronatura Noreste (Service 2009, p. 9). The third is in Texas and the 10-year term of the agreement between this landowner and TPWD expired in 2016. Other populations on privately-owned land have no level of official protection. For any undiscovered sites, it is likely that landowners are unaware of the plant's existence and therefore no effort is made to avoid impacts.

Threats Assessment

When Walker's manioc was listed, threats were believed to include destruction and fragmentation of native brush and grassland habitat. Brush removal, conversion to agricultural purposes, and development pressures increased habitat fragmentation and invasion by nonnative plants, particularly grasses. Due to fragmentation of habitat and the species being confined to remnant tracts of land, surrounded in some cases by cropland, there was also an increased vulnerability to pesticide runoff and drift (Service 1993, p. 11). Introduction of exotic species, especially grasses, was believed at the time to be displacing native vegetation. We now have a greater understanding of the threats to the species, including surface mining of caliche, competition from buffelgrass (*Pennisetum ciliare*), uprooting of plants by javelina and/or feral hogs, destruction of habitat and loss of plants due to urban and residential development as well as from energy-related development (i.e., oil and gas and wind energy).

Invasive grass

Buffelgrass invasion is common to many of the Walker's manioc sites in southern Texas. Buffelgrass is a perennial bunchgrass with a dense growth habit that can result in formation of monoculture vegetation communities and displacement of native vegetation. Exotic grass can displace many native plants by competing for water, preventing seed germination due to its dense root system, and shading the ground (TexasInvasives 2018, unpaginated). Studies in the Sonoran Desert showed that native herbaceous species were displaced by buffelgrass invasion and that nitrogren pollution likely favored buffelgrass over native herbaceous species (Lyons et al. 2013, p. 1). Buffelgrass' high resistance to fire, drought, and grazing make it very persistant (TexasInvasives 2018, unpaginated). Buffelgrass has been observed encroaching into all refuge tract populations (La Puerta, Chicharra Banco, and Yturria Brush Tracts of the LRGV NWR) and Wahl-Villareal noted increasing buffelgrass in the manioc sites at Chicharro Banco and La Puerta NWR tracts in 2015 (K. Wahl-Villareal, 2015, pers. comm.). Buffelgrass was listed at both populations reported by TRC in 2009 (TRC 2, p. 3-10 and p. 3-15). Buffelgrass is also present in the TXDOT's Highway 2221 ROW population, which motivated a volunteer buffelgrass control effort in the spring of 2017. Specific effects of buffelgrass competition on manioc's seed germination, root competition, or other life history aspects are unknown.

Predation
Mammal predation has been observed at several manioc sites. A decline in the La Puerta Refuge Tract's large manioc population by 2007 was attributed to feral hogs uprooting plants (D. Price 2007, pers. comm.). Tuber consumption by javelina was documented on all three aforementioned refuge tracts in the 2009 5-year review, however javelina were also credited with potentially being dispersal agents for the species, as described above. Livestock grazing of manioc has been observed in situations where cattle were obviously starving (Trevino in STPRT 2018, unpaginated). Patterson noted rabbits eating vegetative parts of manioc (in STPRT 2018, unpaginated). Trevino observed that manioc is also a host plant for a butterfly caterpillar (species unknown) (STPRT 2018, unpaginated).

Quarrying/Mining
Google Earth imagery dated January 2017 shows numerous pits or caliche quarries in the area between the most eastern manioc population in southern Texas and Rio Grande City, Texas. Mining is evident on this imagery to both the north and south of Highway 83 with ongoing activity at a number of the sites as evidenced by on-site vehicles. Expansion of a number of these pits can be confirmed by comparing imagery across years. All of the manioc sites in Hidalgo and Starr counties, including some on refuge tracts, are in relatively close proximity to either active quarries or what appear to be old pits that are now full of water, illustrating that the species occurs within a zone of active caliche or gravel quarrying. On private land, known populations are not currently protected by agreements and any undiscovered populations that may exist remain threatened by caliche mining.

Energy Development
At the end of 2018, there were no wind turbines, oil and gas well pads, or roads directly impacting known manioc populations. However, the two south central Starr County manioc population sites were within 4.0 km and 4.8 km from existing turbines at large wind farms to the east and north, respectively. A 56–100-turbine wind farm is proposed for construction to the northwest of these populations. In Starr and Hidalgo counties, there are five existing wind farms (USGS 2019, unpaginated) with some of the 380 turbines atop manioc-appropriate soils. Wind energy development does not have a federal nexus and is not required to carry out surveys for listed species, therefore placement of turbine pads and internal roads could impact undiscovered populations, but the level of impacts is unknown.

U.S./Mexico Border development
Walker's manioc's proximity to the Rio Grande and to HWY 83 increases the vulnerability of the species to development which tends to occur along the river and HWY 83. Proximity to the Rio Grande also means more vulnerability to new roads, new border barriers, increased traffic, and other activities related to increased law enforcement and border security.

AMENDED RECOVERY CRITERIA

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the species is no longer at risk of extinction and may be delisted. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Downlisting is the reclassification of a species from an endangered species to a threatened species. The term

"endangered species" means any species (species, sub-species, or Distinct Population Segment) which is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Revisions to the Lists, including delisting or downlisting a species, must reflect determinations made in accordance with sections 4(a)(1) and 4(b) of the Act. Section 4(a)(1) requires that the Secretary determine whether a species is an endangered species or threatened species (or not) because of threats to the species. Section 4(b) of the Act requires that the determination be made "solely on the basis of the best scientific and commercial data available." Thus, while recovery plans provide important guidance to the Service, States, and other partners on methods of minimizing threats to listed species and measurable objectives against which to measure progress towards recovery, they are guidance and not regulatory documents.

Recovery criteria should help indicate when we would anticipate that an analysis of the species' status under section 4(a)(1) would result in a determination that the species is no longer an endangered species or threatened species. A decision to revise the status of or remove a species from the Federal Lists of Endangered and Threatened Wildlife and Plants, however, is ultimately based on an analysis of the best scientific and commercial data then available, regardless of whether that information differs from the recovery plan, which triggers rulemaking. When changing the status of a species, we first propose the action in the *Federal Register* to seek public comment and peer review, followed by a final decision announced in the *Federal Register*.

In this amendment, we identify one Recovery Unit for Walker's manioc as follows:

Recovery Unit 1 – Hidalgo-Starr Counties, Texas

We also amend downlisting criterion 1 for Walker's manioc which will supercede that included in the original Recovery Plan (Service 2009, pp. 16-17), and we establish delisting criteria as follows:

Downlisting Recovery Criteria
Walker's manioc will be considered for downlisting when the following criteria are met:

1. Within the Hidalgo-Starr Counties, Texas Recovery Unit, establish or maintain 15 distinct, self-sustaining populations of Walker's manioc. Each population should consist of at least 1,000 reproductive individuals.

Justification: Recovery Unit 1 represents the known historical range of Walker's manioc within the U.S. A minimum of 15 populations within Recovery Unit 1 demonstrates that Walker's manioc is sufficiently distributed and abundant within this region to withstand the risk of future catastrophic events, such as the loss of populations to mining, development projects, or conversion to cultivated fields. Maintenance of 15 populations within Recovery Unit 1 also represents a significant increase in the number of known populations at the time of listing, which was 2, and will improve the likelihood of species persistence should a portion or portions of populations be affected by catastrophic events in Hidalgo or Starr counties. A minimum of

1,000 reproductive individuals is the estimated minimum viable population (MVP) using Pavlik's table (Pavlik 1996, p. 137) (Table 1). This MVP represents the population size necessary to endure stochastic environmental variation (resiliency).

Downlisting Criterion 2 and 3 will remain the same as in the original Recovery Plan for Walker's manioc (Service 2009, p. 17).

Delisting Recovery Criteria
Walker's manioc will be considered for delisting when the following criteria are met:

1. Over a 30-year period, maintain at least 15 fully protected, self-sustaining populations containing at least 1,000 reproductive individuals in each, within the known U.S. range.

Justification: To be considered for delisting, all 15 populations of Walker's manioc are stable to increasing at or over the MVP of 1,000 reproductive individuals, as determined by monitoring carried out during years of favorable rainfall patterns so that reproductively active plants can be detected. This trend continues for three 10-year cycles (30 total years) which will enable the range of widely fluctuating plant counts to be captured, as it would include drought that can induce dormancy as well as favorable rainfall patterns that induce reproductive activity, recruitment, and survival. Thus, a 30-year period will allow detection of demographic trends that include the effects of climate (STPRT 2018, unpaginated). Populations must continue to be protected by perpetual agreements and show evidence that threats have been eliminated or controlled. The definition of "fully protected sites" includes management of populations on Federal or State lands as part of an approved management plan (e.g., National Wildlife Refuge Comprehensive Conservation Plans; State highway management agreements for right-of-way populations), or formal stewardship agreements for private landowners that include management and monitoring of the populations and habitat. Management must include measures to reduce or alleviate relevant threats to Walker's manioc, including new threats identified in the 5-year review (STPRT 2018, unpaginated).

Rationale for Amended Recovery Criteria
In this amendment, the maintenance or establishment of 15 populations remains the same as in the downlisting criterion 1 in the original recovery plan; however, the location of the 15 populations is specified to occur within a recovery unit, the Hidalgo-Starr Counties, Texas Recovery Unit. The other populations located in Duval County and in Tamaulipas were not placed within recovery units because they are disjunct and on private lands. Also, it is unknown if the Duval County population is naturally occurring or was introduced (possibly via transfer of road materials containing seeds or tubers). However, the delisting criterion applies to any U.S. population and can include populations located outside of the Hidalgo-Starr Counties, Texas Recovery Unit.

The Walker's manioc's demographic criteria from the original recovery plan are upheld in part, although specifications of size class structure are discarded. In the original recovery plan, the target number of populations was based on achieving a significant increase in known populations at the time of listing, as well as the potential for finding new populations in unsurveyed areas or creating new populations through reintroduction efforts. The STPRT indicated support for

retaining 15 populations as the target for reclassification to help increase redundancy beyond existing levels (STPRT 2018, unpaginated). The number of individual plants constituting a viable population has been updated from 100 to 1,000 reproductive individuals based on the STPRT's recalculation of an estimated minimum viable population (MVP) using Pavlik's table (Pavlik 1996, p. 137) (Table 1). This recalculation relied on the knowledge and experience of members of the STPRT and from the most updated information regarding the species' biology and ecology.

Table 1. Minimum viable population guidelines applied to Walker's manioc (adapted from Pavlik 1996, p. 137). Factors in bold are those identified by the STPRT to best describe Walker's manioc.

Factor	A. MVP of 50 individuals for species with these traits.	B. Intermediate MVP of 1,000 individuals for species with intermediate or unknown traits.	C. MVP of 2,500 individuals for species with these traits.
Longevity	**Perennial**		Annual
Breeding System	**Selfing**		Outcrossing
Growth Form	Woody	**Intermediate**	Herbaceous
Fecundity	High		**Low**
Ramet Production	**Common**		Rare or None
Survivorship	High	**Intermediate**	Low
Longevity of Seed Viability	Long	**Intermediate**	Short
Environmental Variation	Low		**High**
Successional Status	**Climax**		Seral or Ruderal

Plant counts at any given site during/following unfavorable weather conditions could result in misleading conclusions regarding the population's size. Populations can appear to be in decline because leaves and stems can die back during adverse conditions; however, tubers persist underground and plant counts can rebound when conditions are conducive for growth. The ephemeral nature of the aboveground plant material necessitates surveying and monitoring during favorable environmental conditions, and the appearance and subsequent disappearance of plants at the same site may contribute to the inconsistent numbers of plants reported at the same sites during repeated visits. Therefore, the recovery criterion was changed to reflect measurement of population size and stability from counts of individual reproductive plants only with no size class structure requirement. By counting only reproducing plants, we are using plants that have demonstrated survival and establishment as perennials.

Because Walker's manioc population size, as well as the species' persistence, is closely associated with cycles of precipitation and drought, we stipulated monitoring over 10-year cycles that include drought and rainfall peaks in the de-listing recovery criterion. This climate-based, 10-year cycle was calculated using National Centers for Environmental Information data from seven stations located between McAllen and Laredo, Texas (National Centers for Environmental Information 2018, unpaginated). The wide fluctuations in population size among years meant

that judgement regarding success or failure of management practices should not be based on results after one to two years, but instead that a 10-year evaluation period would be more appropriate.

In addition to a lack of knowledge of reproductive connectivity between existing populations, uncertainties also remain regarding the life span and the viability of the seed bank. The STPRT stressed the need to investigate these life history aspects in order to further refine recovery criteria. Knowledge of generation time and seed bank viability would help to validate or potentially change the monitoring time period needed to show that the species is stable or increasing in its natural habitat (STPRT 2018, unpaginated).

Downlisting Criterion 2 in the original recovery plan requires establishment of agreements for protection and management of the populations described in Downlisting Criterion 1. We have expanded upon this by stating that agreements need to be perpetual in order for Walker's manioc to be considered for delisting. Although voluntary agreements were indicated in the recovery plan as acceptable in the interim (for down-listing), the STPRT indicated support for a more permanent level of protection for the 15 populations. The new de-listing criteria stipulate permanent protection as well (STPRT 2018, unpaginated).

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