

Recovery Plan for the Sonoyta Mud Turtle

(Kinosternon sonoriense longifemorale)



*Juvenile Sonoyta mud turtle (Kinosternon sonoriense longifemorale) from the Rio Sonoyta, Sonora, Mexico.
Photo by Glenn Knowles, U.S. Fish and Wildlife Service.*

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Approved: _____
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PURPOSE AND DISCLAIMER

This document presents the U.S. Fish and Wildlife Service's (USFWS) recovery plan for the conservation of the Sonoyta mud turtle. The recovery plan is the second part of the USFWS 3-part recovery planning framework and includes the statutorily required elements pursuant to section [4\(f\)](#) of the Endangered Species Act (ESA). This recovery plan is informed by the first part of the framework, a Species Status Assessment (SSA). The SSA report delivers foundational science for informing decisions related to the ESA and includes an analysis of the best available scientific and commercial information regarding the subspecies' life history, biology, and current and future conditions that characterize the subspecies' viability (i.e., ability to sustain populations in the wild over time) and extinction risk. **We will also prepare a Recovery Implementation Strategy (RIS), the third part of the framework. The RIS is an easily updateable operational plan that is separate and complementary to the recovery plan that details the on-the-ground recovery activities needed to complete the recovery actions contained in the recovery plan.**

Recovery plans describe the envisioned recovered state for a listed entity (when it should no longer meet the ESA's definitions of a threatened or endangered species or subspecies). Recovery plans lay out a recovery strategy, recovery criteria, recovery actions, and estimates of time and cost needed to achieve recovery. Plans are published by the USFWS and are often prepared with the assistance of recovery teams, contractors, state agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than the USFWS. Recovery plans represent the official position of the USFWS only after they have been signed by the Regional Director as approved. Recovery plans are guiding and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in subspecies status of the listed entity, and completion of recovery actions.

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RECOMMENDED CITATION AND ELECTRONIC AVAILABILITY

U.S. Fish and Wildlife Service. 2026. Recovery Plan for Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*). U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico, USA. 24 pp.

An electronic copy of this Recovery Plan will be made available at:
<https://ecos.fws.gov/ecp/species/7276>.

1. INTRODUCTION

This recovery plan identifies a recovery priority number for the Sonoyta mud turtle, defines criteria for determining when the Sonoyta mud turtle should be considered for downlisting and delisting, lists site-specific actions that will be necessary to meet those criteria, and estimates the time and cost to achieve recovery. Additionally, a summary of information on the subspecies' biology and status is included, along with a brief discussion of factors limiting its populations. A detailed discussion of these and other topics pertinent to the recovery of the Sonoyta mud turtle can be found in the Species Status Assessment (SSA; USFWS 2017, entire). Detailed, on-the-ground activities implementing recovery actions will be available in the Recovery Implementation Strategy (RIS). These supplemental documents are or will be available at <https://ecos.fws.gov/ecp/species/7276>. The RIS and SSA are finalized separately from the Recovery Plan and will be updated on a routine basis.

1.1 Recovery Priority Number

Sonoyta mud turtle is assigned a recovery priority number of 6c on a scale from 1 to 18, where 1 represents the highest recovery priority (48 FR 43098). The 6 indicates that this subspecies faces a high degree of threat and has a low recovery potential; the “c” indicates there is a potential conflict, in this case with groundwater use. The degree of threat to the subspecies is high due to the ongoing loss of aquatic and riparian habitat caused by drought and groundwater pumping, both of which are exacerbated by climate change. The Sonoyta mud turtle has a low recovery potential due to continued human development and associated groundwater use in the Rio Sonoyta basin as well as continued drought and climate change.

1.2 SSA Report Overview with Updated Information

The following overview summarizes life history information, habitat needs, distribution and abundance, and threats to the Sonoyta mud turtle. For a more thorough review of these topics, see the SSA report for the Sonoyta Mud Turtle (USFWS 2017, entire).

1.2.1 Species Description and Life History

The Sonoyta mud turtle is an isolated, endemic subspecies of the Sonora mud turtle (*Kinosternon sonoriense*) found in southern Arizona and northwestern Sonora, Mexico. The Sonoyta mud turtle is a small, dark, freshwater turtle that depends on aquatic and terrestrial habitat. Sonoyta mud turtles need perennial or near-perennial surface water for feeding, protection from predators, preventing desiccation, and mating. The subspecies also requires terrestrial riparian habitat with moist soil during nesting and estivation (a state of dormancy) to prevent desiccation of eggs, hatchlings, juveniles, and adults. Sonoyta mud turtles are opportunistic carnivores, feeding primarily on aquatic invertebrates that live on emergent and submergent vegetation or the substrate of ponds and streams.

Monitoring of turtle populations in the Rio Sonoyta has been episodic, complicating our understanding of the subspecies' longevity. Thus, the longevity of Sonoyta mud turtles across populations in the wild is not well known, but likely ranges between 10 (Rosen 1986, p. 30) and 40 years (Stone et al. 2022, p. 12). The oldest individuals documented to date come from Quitobaquito Springs, where monitoring has been the most long-term and consistent and habitat is protected. Female turtles may become sexually mature as early as six years and males around four years (Rosen and Lowe 1996, pp. 14–16). Mating occurs in water from April to late June. Ovulation and shelling of eggs begin in June, and eggs remain in the oviducts until the monsoon rains from mid- to late-July through September (van Loben Sels et al. 1997, p. 343). During this time, females briefly leave the water to lay eggs in terrestrial nests. Eggs undergo delayed embryo development in the nest for up to 11 months. Development then begins as eggs warm during the following spring, and full development takes about 80 days. Hatchlings emerge and disperse from the nest coinciding with the onset of summer rains (van Lobel Sels et al. 1997, p. 343; Ernst and Lovich 2009, p. 497; Stone et al. 2015, p. 735).

1.2.2 Status and Distribution

The Sonoyta mud turtle was listed as endangered by the USFWS in 2017 (82 FR 43897), and 12.28 acres (4.97 hectares) within Organ Pipe Cactus National Monument in southwestern Arizona were designated as critical habitat in 2020 (85 FR 37576).

The Sonoyta mud turtle is limited in its distribution to the Rio Sonoyta basin in Arizona and Sonora, Mexico and one additional site in Mexico at Quitovac. The subspecies was historically known from five sites, including one site in the U.S. and at least four sites in Mexico. One of the historical populations in Sonora is believed to be extirpated (Santo Domingo), and four new populations have been discovered (Quitovac, Sonoyta Sewage Lagoon, Loma Alta, and the Morelia Reach). One newly discovered population, Sonoyta Sewage Lagoon, was functionally extirpated after the sewage lagoon dried and a fire burned the site in 2019, and another fire burned the remaining habitat in the lagoon's forebay in 2026. The Sonoyta mud turtle currently occurs as one population in Arizona, and three to five populations in Sonora, Mexico (**Table 1** and **Figure 1**).

Based on the SSA, we delineate a population of Sonoyta mud turtle as a group of interbreeding individuals living in an ecological community separated from other populations by barriers (e.g., desert upland not connected by riparian or xeroriparian habitat or in-channel distances that lack water most of the time). Periodic movement between populations may occur during periods of high rainfall, but frequent immigration and emigration are thought to be unlikely (USFWS 2017, p. 24).

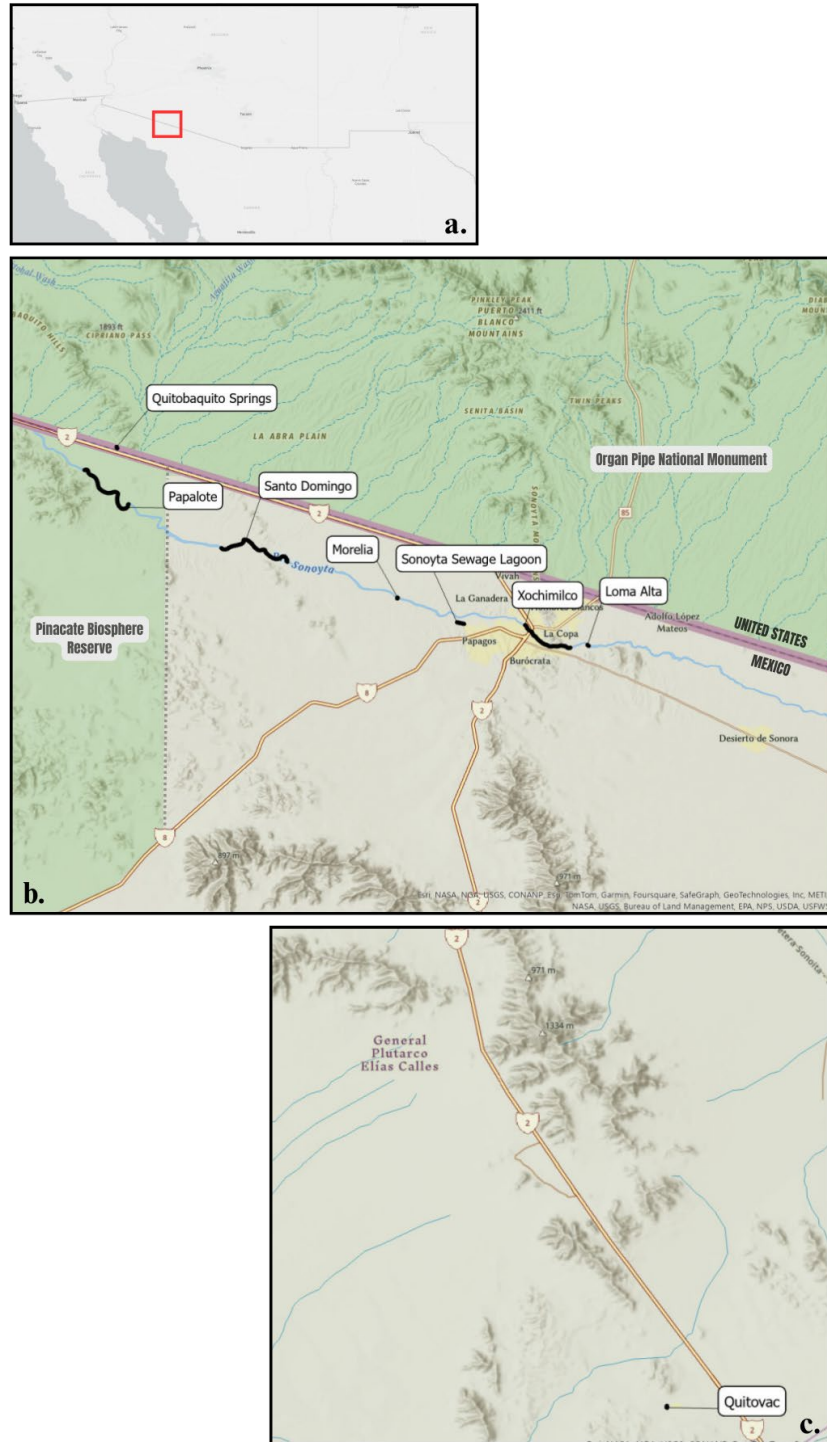


Figure 1. Current and historical range and distribution of Sonoyta mud turtle in the U.S. and Mexico. Figure 1a shows the general region where Sonoyta mud turtles are found. Figures 1b and 1c show where current and historical populations of Sonoyta mud turtle exist or previously existed on the landscape. Figure 1c shows the population at Quitovac which is approximately 24 miles south of the Town of Sonoyta.

Table 1. Status of current and historical populations of Sonoyta mud turtle. In the context of current status, “present” indicates that turtles have been observed at the site within the last five years, and “unknown” indicates that no observations of turtles have been made in the last five years. This may mean that no turtles were found in a survey or that no surveys have been conducted. “Unknown” in terms of trend indicates that we do not have enough information to estimate an increasing, stable, or decreasing population trend. In the case of Santo Domingo and the Sonoyta Sewage Lagoon, “functionally extirpated” indicates that though a handful of turtles may still be present, we anticipate the remaining populations are too small to be reproductively viable.

Subpopulation	Location	Land Management	Condition in 2017 SSA	Current Status and Trend
Quitobaquito Springs	Quitobaquito Springs, Arizona	Organ Pipe Cactus National Monument, National Park Service	Moderate	Present and stable
Papalote Reach	Rio Sonoyta, Sonora	Pinacate Biosphere Reserve / Ejido Cerro Colorado	Moderate	Present and decreasing
Santo Domingo	Rio Sonoyta, Sonora	Ejido Josefa Ortiz de Dominguez	Functionally Extirpated	Functionally Extirpated
Morelia Reach	Rio Sonoyta, Sonora	Ejido Morelia	--	Present and unknown
Sonoyta Sewage Lagoon	Rio Sonoyta, Sonora	Oomapas (municipal water company)	Moderate	Functionally Extirpated
Xochimilco Reach	Rio Sonoyta, Sonora	Town of Sonoyta	Low	Present and decreasing
Loma Alta	Rio Sonoyta, Sonora	Ejido Lopez Mateos	--	Present and unknown
Quitovac	Quitovac, Sonora	Quitovac y su anexo el Chujubabi	Low	Unknown and unknown

In the U.S., Sonoyta mud turtles are currently present at Quitobaquito Springs, and the population is considered stable. In Mexico, the Papalote Reach population is still present but declining. The Sonoyta Sewage Lagoon population is considered functionally extirpated. The Xochimilco and Loma Alta locations may maintain small populations of turtles now and into the future, but both locations will need more water to support healthy turtle populations. Xochimilco dries for long periods of time, in part because the area no longer receives water from the nearby, decommissioned military base. Though the Loma Alta Reach contains pooled water much of the year, the site is small (usually no more than 0.1 hectares [0.25 acres] of water) (Grageda and Bogan 2025, p. 156). The Morelia population became established in 2019, when new sewage treatment ponds came online, and this location may be the best stable habitat into the future in Mexico (Grageda-Garcia 2023, pp. 79-85). The Santo Domingo location contains some ephemeral water that may last for weeks after rainy seasons, but turtles have not been observed there since the early 1990s. The status of the Quitovac population is unknown, as the area has been opportunistically monitored and has not been visited in nearly 10 years.

The Sonoyta mud turtle occurs in three representation areas: Quitobaquito Springs, the Rio Sonoyta (Papalote and Xochimilco), and Quitovac. Genetic investigations (Rosen 2003, pp. 8–13; Rosen et al. 2006, p. 10) indicate that the subspecies exhibits some level of genetic diversity among Quitobaquito Springs, the Rio Sonoyta (Papalote and Xochimilco), and Quitovac. Populations in the Sonoyta sewage lagoon, Morelia, and Loma Alta were not sampled. Exchange of genetic material between Quitobaquito Springs and populations along the Rio Sonoyta is unlikely due to the lack of hydrological connection, and exchange of individuals has not been observed despite mark-recapture efforts at these sites (Paredes-Aguilar and Rosen 2003, p. 9).

1.2.3 Threats

The primary threat affecting the viability of the Sonoyta mud turtle is the continued loss of water that supports aquatic and riparian habitat. Sources of water loss include groundwater pumping, drought, changes to wastewater infrastructure, consumption by livestock, surface water diversion, and habitat manipulation. Of these sources, water loss caused by drought and groundwater pumping (both of which are exacerbated by climate change) and changes to wastewater infrastructure are the primary causes of population-level impacts to the Sonoyta mud turtle.

Beyond ongoing water loss, the Sonoyta mud turtle faces additional threats, including dredging at Quitovac and potential predation by and competition with nonnative species (e.g., predation by bullfrogs, crayfish, centrarchids, and ictalurids and competition with black bullheads [*Ameiurus melas*], African cichlid fishes [tilapia], western mosquitofish [*Gambusia affinis*], and exotic turtles). These stressors, combined with habitat degradation, have resulted in an estimated 80-90% reduction in the subspecies' range within the Rio Sonoyta, Mexico. Consequently, the subspecies' representation, resiliency, and redundancy have been impacted, with none of the five

extant populations evaluated in 2017 meeting the criteria for "high" resiliency (USFWS 2017, entire; **Table 1**).

2. RECOVERY GOAL

The recovery goal is to ensure the long-term persistence of the Sonoyta mud turtle in the wild over time (i.e., viability) through increasing the number of individuals and populations, restoring and conserving habitat, and reducing threats to the subspecies and its habitat; thus, allowing for removal of Sonoyta mud turtle from the Federal Lists of Endangered and Threatened Wildlife and Plants pursuant to 50 CFR 17.11 (i.e., recovery). When recovered, Sonoyta mud turtles will demonstrate (1) resiliency by having naturally occurring and successfully introduced viable populations, and (2) redundancy and representation by having genetically and ecologically diverse populations distributed across multiple locations throughout the subspecies' range. Threats to long-term viability will be reduced and habitat restored and conserved such that sufficient habitat quantity and quality are available to support the long-term survival of the subspecies.

Importantly, actions taken to recover the Sonoyta mud turtle are likely to benefit other listed and imperiled species in the region (e.g., Quitobaquito pupfish [*Cyprinodon macularius eremus*]).

3. RECOVERY STRATEGY

The recovery strategy provides a concise overview of the envisioned recovered state for the Sonoyta mud turtle, describes the USFWS's chosen approach to achieve it, and includes the rationale for why the approach was chosen. Specifically, the recovery strategy articulates how the plan's statutory elements (recovery criteria, recovery actions, and estimates of time and cost) will work together to achieve Sonoyta mud turtle recovery.

The strategy identifies the following outcomes (through criteria and recovery actions) that will lead to achieving the goal of recovery of the Sonoyta mud turtle:

1. Ensure that extant populations of Sonoyta mud turtles continue to exist in the U.S. and Mexico *in situ*.
2. Manage, restore, and protect the quantity and quality of Sonoyta mud turtle habitat for the long-term survival of the subspecies in the U.S. and Mexico.
3. Improve our understanding of current conditions, trends, threats, and outcomes of management actions through monitoring of all Sonoyta mud turtle populations and their habitats.
4. Improve our understanding of Sonoyta mud turtle ecology, biology, viability, genetics, threats, compatible land uses, and habitat restoration through scientific research, thereby enabling better management of the subspecies.

5. Increase the number of populations and maintain populations, such that the subspecies is viable, via successful Sonoyta mud turtle captive breeding, augmentation of existing populations, and introduction of new populations.
6. Ensure long-term Sonoyta mud turtle conservation through the establishment of refuge populations housed at multiple institutions.

4. RECOVERY CRITERIA

Recovery criteria are statutorily required objective, measurable descriptions of a recovered state for the Sonoyta mud turtle, as described in [4\(f\)\(1\)\(b\)\(ii\)](#) of the ESA. Recovery criteria describe the conditions of resiliency, redundancy, representation, and threat abatement that indicate when the Sonoyta mud turtle may no longer meet the ESA's definitions of an endangered or threatened subspecies. Recovery criteria present our best assessment of the subspecies' recovered condition at the time of recovery plan development. Because we cannot envision the exact course that recovery may take, and because our understanding of the vulnerability of a species to threats is likely to change as more is learned about the species and the threats, it is possible that a status review may indicate that delisting is warranted even if not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met, and a status review may indicate that delisting is not warranted. For example, a new threat may emerge that is not addressed by the current recovery criteria. Thus, changes in available information, technologies, and our understanding of the subspecies over time might mean that the recovered state envisioned by these recovery criteria differs from our assessment in a later status determination.

Downlisting Criteria

The following downlisting criteria, when met collectively, would indicate that the Sonoyta mud turtle may be reclassified as a threatened subspecies.

Downlisting Criterion 1:

At least five populations are maintained throughout the subspecies' range in the U.S. and Mexico, including the following populations:

- At least one population in Quitobaquito Springs in Arizona;
- At least two populations in the subspecies' historical range in the Rio Sonoyta in Sonora (e.g., Papalote, Morelia, Xochimilco, and Loma Alta); and
- At least two additional populations in the greater Sonoyta region (e.g., Quitovac).

Downlisting Criterion 2:

At least four populations show a stable or increasing population trend over a consecutive 10-year period with evidence of recruitment.

Downlisting Criterion 3:

Genetic diversity is protected and maintained for newly established wild and captive populations by maintaining at least 90 percent of genome-wide heterozygosity present in the source population.

Downlisting Criterion 4:

Habitat at Quitobaquito Springs is protected and maintained, and habitat within the Rio Sonoyta and the Sonoyta region in the U.S. and Mexico is improved and maintained. In areas supporting Sonoyta mud turtle populations, land management and site-specific plans are developed and implemented, such that over a consecutive 10-year period:

- a. Total habitat availability is maintained or improved (e.g., number of water bodies such as pools, lagoons, or river reaches); and
- b. habitat and/or flow restoration efforts retain surface water in the Rio Sonoyta.

Justification for Downlisting Recovery Criteria:

Justification for Recovery Criterion 1: The Sonoyta mud turtle requires multiple resilient populations distributed across its historical range to ensure that a catastrophic event does not result in the loss of the entire subspecies. The Recovery Team determined that maintaining at least five populations across the U.S. and Mexico would enhance the species' ability to withstand stochastic events while ensuring sufficient connectivity, redundancy, and representation to support long-term survival.

Currently, only one population exists in the U.S. at Quitobaquito Springs in Arizona; thus, this population needs to be maintained. In Mexico, populations exist throughout the subspecies' historical range at Papalote, Morelia, Loma Alta, and Xochimilco; however, these populations vary in their resiliency and ability to persist through stochastic events. An additional population of turtles may still be present at Quitovac, but the status of that population is unknown. Depending on the resiliency of these populations, additional populations in the greater Sonoyta region may need to be established for the conservation and downlisting of the subspecies.

Justification for Recovery Criterion 2: A stable or increasing population trend over a consecutive ten-year period will demonstrate population resiliency across multiple cohorts and at least one generation assuming a minimum reproductive age of six and four years for females and males, respectively (Rosen and Lowe 1996, pp. 14–16). If at least four populations demonstrate a stable or increasing population trend and show evidence of recruitment, the subspecies is more likely to have the redundancy and representation it needs to survive catastrophic events and be viable.

Justification for Recovery Criterion 3: Sonoyta mud turtles need genetic and ecological diversity to adapt to changing environmental conditions. The more representation, or diversity, a

subspecies has, the more the subspecies can adapt to changes (natural or human-caused) in its environment. Genetic analysis conducted in the mid-2000s reveals that Sonoyta mud turtle populations have likely been connected in the past (Rosen et al. 2006, p. 10); however, the ongoing loss of water and habitat have led to increased fragmentation and isolation of extant populations. Maintaining genetic diversity within and among populations, along with habitat connectivity where feasible, are needed to downlist the Sonoyta mud turtle. In particular, the loss of Quitobaquito Springs, Quitovac, or the Rio Sonoyta populations would substantially reduce the representation (genetic and ecological) for the subspecies.

Retaining 90% of the original genetic diversity has been widely used as a conservation genetics management target, particularly in captive breeding and genetic management programs. Though this threshold does not guarantee genetic health, it is a practical, measurable benchmark for evaluating whether newly established populations have retained most of the genetic diversity present in the source population (Frankham et al. 2010, pp. 644-682; and Frankham 2022, entire).

Justification for Recovery Criterion 4: Habitat for the Sonoyta mud turtle needs to be protected and maintained at Quitobaquito Springs and improved and maintained throughout the Rio Sonoyta. Site-specific restoration and management plans will need to be developed and implemented.

Delisting Criteria

The following delisting criteria, when met collectively, may indicate that the Sonoyta mud turtle no longer meets the ESA's definitions of either a threatened subspecies or endangered subspecies, and may be able to be removed from the Federal Lists of Endangered and Threatened Wildlife and Plants.

Delisting Criterion 1:

Seven populations are stable and maintained throughout the subspecies' range in the U.S. and Mexico, including the following populations:

- At least one population in Arizona;
- At least three populations in the subspecies' historical range in the Rio Sonoyta in Sonora (e.g., Papalote, Morelia, Xochimilco, and Loma Alta); and
- At least three additional populations in the Sonoyta region (e.g., Quitovac).

Delisting Criterion 2:

At least six populations show a stable or increasing population trend over a consecutive 20-year period with evidence of recruitment.

Delisting Criterion 3:

Genetic diversity is protected and maintained for newly established wild and captive populations by maintaining at least 90 percent of genome-wide heterozygosity present in the source population.

Delisting Criterion 4:

Habitat at Quitobaquito Springs is protected and maintained, and habitat within the Rio Sonoyta and the Sonoyta region in the U.S. and Mexico is improved and maintained. In areas supporting Sonoyta mud turtle populations, land management and site-specific plans are developed and implemented, such that over a consecutive 20-year period:

- a. total habitat availability is maintained or improved (e.g., number of water bodies such as pools, lagoons, or river reaches); and
- b. habitat and/or flow restoration efforts retain surface water in the Rio Sonoyta.

Delisting Criterion 5:

Additional threats, especially predation by and competition with nonnative species, to the Sonoyta mud turtle and its habitat at Quitobaquito Springs and throughout the Rio Sonoyta are managed through cooperation with local, regional, and national entities, such that Delisting Criteria 1 through 4 are met.

Justification for Delisting Recovery Criteria:

Justification for Recovery Criterion 1: The additional two populations required for delisting would further increase the redundancy of the subspecies. This would include at least one population in Arizona, at least three populations in the subspecies' historical range in the Rio Sonoyta, and at least three additional populations in the greater Sonoyta region for a total of seven populations.

Justification for Recovery Criterion 2: A stable or increasing population trend over a 20-year period will demonstrate population resiliency across multiple cohorts and at least two generations assuming a minimum reproductive age of six and four years for females and males, respectively (Rosen and Lowe 1996, pp. 14–16) and a durable, positive response to long-term threats abatement. If at least six populations demonstrate a stable or increasing population trend and show evidence of recruitment, the subspecies is more likely to have the redundancy and representation it needs to survive catastrophic events and be viable.

Justification for Recovery Criterion 3: See Downlisting Criterion 3 justification, above.

Justification for Recovery Criterion 4: A consecutive 20-year period, which is twice the period for downlisting, would demonstrate a durable, positive response to long-term threats abatement and habitat management.

Justification for Recovery Criterion 5: Additional threats, especially predation by and competition with nonnative species, to the Sonoyta mud turtle and its habitat at Quitobaquito Springs and throughout the Rio Sonoyta must be managed to justify delisting. Establishment of some nonnative aquatic vertebrate species may affect future persistence of the Sonoyta mud turtle. Nonnative species like black bullheads, western mosquitofish, golden shiners *Notemigonus crysoleucas*, and red-eared sliders *Trachemys scripta elegans* have been found at four sites (Papalote, Quitovac, Quitobaquito Springs, and Xochimilco; USFWS 2017, p. 64). Other nonnative aquatic species, including bullfrogs, crayfish, and centrarchids are not currently present in areas occupied by the Sonoyta mud turtle, but could be released and become established as they have been in many of the nominate Sonora mud turtle populations in the U.S. (Fernandez and Rosen 1996, pp. 39–41; Hensley et al. 2010, pp. 175–176; Drost et al. 2011, p. 33). These species are known to prey upon hatchlings and juvenile mud turtles. Management actions regarding threats abatement will need to be implemented in cooperation with local, regional, and national entities to properly address threats to the subspecies.

5. RECOVERY ACTIONS

Recovery actions are the statutorily required, site-specific management actions needed to achieve recovery criteria, as described in section [4\(f\)\(1\)\(B\)\(i\)](#) of the ESA. The USFWS assigns recovery action priority numbers (1-3) to rank recovery actions. The assignment of priorities does not imply that some recovery actions are of low importance but instead indicates that lower priority items may be deferred while higher priority items are being implemented. Recovery action priority numbers are based on the following:

- Priority 1:** An action that must be taken to prevent extinction or to prevent the subspecies from declining irreversibly.
- Priority 2:** An action that must be taken to prevent a significant decline in subspecies population/habitat quality, or some other significant negative impact short of extinction.
- Priority 3:** All other actions necessary to provide for full recovery of the subspecies.

Table 2. Recovery action summary table.

Action #	Priority #	Site-Specific Recovery Action	Recovery Criteria	Action Duration (years)	Estimated Total Cost
1	1	Develop standardized monitoring protocols to monitor all Sonoyta mud turtle populations and habitat in the U.S. and Mexico.	1 and 2	2	3K
2	1	Monitor all Sonoyta mud turtle populations in the U.S. and Mexico following standardized monitoring protocols.	1 and 2	25	100K
3	1	Monitor all Sonoyta mud turtle habitat following standardized monitoring protocols and assess if improvements are needed.	4	25	100K
4	2	Assess areas where new populations could be reestablished or introduced.	3 and 4	3	9K
5	2	Investigate existing genetic diversity within and among populations in the U.S. and Mexico, including existing heterozygosity such that criterion 3 can be evaluated.	3	3	90K
6	1	Establish and maintain two assurance populations to enhance existing populations or create new populations. Use the best available science to determine the minimum population size, size/age distribution, and sex ratio of turtles needed (e.g., Riedle et al. 2012, entire).	1	25	250K

Action #	Priority #	Site-Specific Recovery Action	Recovery Criteria	Action Duration (years)	Estimated Total Cost
7	1	Manage, restore, and protect the quantity and quality of Sonoyta mud turtle habitat for the long-term survival of the subspecies, especially any improvements identified in action 3.	4	20	600K
8	3	Manage predation by and competition with nonnative species through coordination with local, regional, and national entities.	5	10	150K
9	1	Assess outcomes of management actions and if threats have been abated through monitoring of all Sonoyta mud turtle populations and its habitat.	1, 2, 4, and 5	25	accounted for in monitoring costs
10	3	Improve our understanding of Sonoyta mud turtle ecology, biology, viability, genetics, threats, compatible land uses, and habitat restoration through scientific research, thereby enabling better management of Sonoyta mud turtle.	all	15	300K

Action #	Priority #	Site-Specific Recovery Action	Recovery Criteria	Action Duration (years)	Estimated Total Cost
11	2	Establish a Working Group to meet annually to coordinate, track, and evaluate recovery efforts and funding opportunities.	all	25	12.5K
12	3	Develop and implement an outreach and communications plan for the Sonoyta mud turtle. Include key messages and methods of disseminating information such as regular meetings, social media, USFWS webpages, news outlets, etc.	1, 2, 4, and 5	25	25K

6. ESTIMATED TIME AND COSTS TO ACHIEVE RECOVERY

Estimates of time and cost, as defined in section [4\(f\)\(1\)\(B\)\(iii\)](#) of the ESA, must reflect, to the maximum extent practicable, the total amount of time and costs it will take to achieve the recovery (delisting) of the Sonoyta mud turtle. The cost estimates provided do not account for possible future inflation.

We estimate that the full implementation of the recovery actions would improve the status of Sonoyta mud turtle so that it could be delisted within 27 years following the adoption of this recovery plan and cost \$1,639,500 dollars. We note that the recovery program may change over time, or the timeframe estimated to implement the recovery actions to achieve recovery of the subspecies may take longer than expected. The recovery of Sonoyta mud turtle will depend largely on the commitment and the ability of the USFWS and partners to implement the recovery actions necessary to achieve the recovery criteria.

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APPENDIX A. USFWS RESPONSE TO PEER REVIEW AND PUBLIC COMMENT

The initial draft of this recovery plan was completed by the formal Sonoyta Mud Turtle Recovery Team. The USFWS then initiated a 30-day public comment period starting August 28, 2025, and closing on September 29, 2025. During the public comment period, the USFWS also requested peer and technical review from six species experts and groups. We received responses from three peer reviewers and two technical reviewers. During the public comment period, we received comments from seven commentors. We made edits to the recovery plan as described below, and in some instances, additional language and/or citations were added to the recovery plan for clarity. A summary of comments and our responses are provided below.

Comment: We received suggestions for some minor changes and corrections throughout the document (e.g., spelling errors, grammatical revisions, location references, and additional references) to improve readability and clarity of the document.

Response: We incorporated these comments and edits as appropriate. A full summary of such changes is not provided.

Comment: One commentor requested that we note challenges in longevity data collection and explain why sites like Quitobaquito Springs report longer-lived individuals.

Response: We edited the section on life history to qualify that longevity data are not necessarily available across the subspecies' range and that the population at Quitobaquito Springs is more frequently monitored and the habitat is protected.

Comment: One commentor expressed confusion regarding the timing of hatchling emergence.

Response: We revised the language to clarify that hatchlings emerge about a year after eggs are laid.

Comment: One commentor clarified that the Sonoyta mud turtle originated in the Rio Colorado and has been present at Quitovac—both outside the Rio Sonoyta basin.

Response: When referring to the distribution of the species, we have revised our language to be inclusive of Quitovac and to refer to the Rio Sonoyta basin and Quitovac as the current distribution of the species as opposed to the historical distribution of the species.

Comment: One commentor clarified that exotic turtles are likely competitors with Sonoyta mud turtles as opposed to predators.

Response: This is also how the interaction is described in the final listing rule and the 2017 SSA; we have revised the language to reflect this.

Comment: One commentor clarified that no bullfrogs, crayfish, or exotic turtles have been found with Sonoyta mud turtles in Mexico.

Response: We revised the language in this plan to clarify that predation by or competition with these species is a “potential” threat.

Comment: Several commentors requested that we further define “population” and “population status.”

Response: We recognize having a definitive number of individuals needed for a viable population is ideal; however, we currently do not have those data for wild populations. We have included a reference to Riedle et al. (2012) in recovery action 6. This study completed a population viability analysis and determined the minimum number of turtles needed to support an assurance colony.

We hope that the revised recovery criteria and implementation of actions recommended in this plan will further elucidate the size needed for viable wild populations. We can then include that information in the upcoming Recovery Implementation Strategy (RIS) and revise that information as updated data are available.

Comment: One commentor requested clarification for the terms used in **Table 1** (i.e., “unknown” and “functionally extirpated”).

Response: These terms have been clarified in the caption of **Table 1**.

Comment: One commentor requested that three populations be established in the Rio Sonoyta as a downlisting criterion instead of the two populations proposed.

Response: We maintain that two populations on the Rio Sonoyta serve as a good threshold at which to reevaluate the subspecies for downlisting. Historically, only three populations existed on the Rio Sonoyta, and while there are currently turtles at four sites on the Rio Sonoyta, the status of those populations varies and in some cases is unknown.

Comment: We received several suggestions for suitable sites where Sonoyta mud turtle might be introduced.

Response: We are keeping a record of these suggestions for use in the upcoming RIS.

Comment: One commentor asked that we provide more context regarding how life history traits might influence management, conservation strategies, and recovery goals.

Response: We have added information in the justifications for our criteria to better connect the life history of the subspecies to the criteria we recommend.

Comment: Several commentors expressed concern regarding the timelines used in the down- and delisting criteria.

Response: We added language clarifying the number of cohorts and generations we anticipate the 10- and 20-year periods to cover based on research from Rosen and Lowe 1996.

Comment: Several commentors requested that criterion 3 and action 5 regarding genetic diversity be made more objective and measurable.

Response: We have revised criterion 3 and action 5 to include an objective and measurable metric of genetic diversity (i.e., heterozygosity). While heterozygosity is not the only metric to evaluate genetic diversity, this metric serves as a starting point, and the 90-percent threshold is widely accepted as a conservation genetics management target (Frankham et al. 2010, pp. 644-682). As required by the ESA, we would consider all of the best available scientific and commercial information when evaluating the subspecies' status (e.g., any information available regarding inbreeding and relatedness).

Comment: One commentor requested that we summarize current genetic findings and clearly outline the steps needed to address data gaps, including timelines for new genetic surveys and integration of results into management actions. This commentor also suggested the use of Evolutionarily Significant Units (ESUs) to define populations of Sonoyta mud turtle.

Response: We provide a brief genetic summary in the justification for criterion 3. A more thorough summary of the subspecies' genetics can be found in the most recent SSA and Five-year Status Review. Timelines for genetic research and how that research will be used to inform management actions will be included in the RIS. We have clarified the relationship between action 5 and criterion 3 and how action 5 will support our evaluation of criterion 3.

Currently, no studies have identified or defined ESUs within the listed subspecies. As new information becomes available, we will incorporate it into our recovery efforts.

Comment: One commentor expressed concern over the reality of maintaining or increasing water levels at Quitobaquito Pond over a 20-year period.

Response: We removed language on water levels from the delisting and downlisting criteria, recognizing that even if water levels decrease, the habitat at Quitobaquito could still be used by the turtle. We will include an activity on monitoring water levels at Quitobaquito Pond in the RIS.

Comment: One commentor suggested that we include an action to establish a Working Group to evaluate recovery efforts annually.

Response: We added action 11 which prompts the Recovery Team and the USFWS to establish a Working Group to coordinate recovery efforts for the Sonoyta mud turtle.

Comment: One commentor suggested that we include an action related to outreach and communication to help inform the public about the turtle and what they can do to help recover the subspecies.

Response: We added action 12 which prompts the Recovery Team and the USFWS to develop and implement an outreach and communications plan in support of the recovery criteria.

Comment: Several commentors expressed concern regarding the amount and allocation of funds, especially our estimates of funding for genetic research and management.

Response: The estimates included in the recovery plan represent our best understanding at the time regarding what each action will cost. Recovery plans and the cost estimates therein do not impact federal allocation of funds. Instead, the estimates serve to help our partners understand the funding likely needed to complete each action. The funding for each action will still need to be secured. We may provide more granular detail on the costs of activities related to each action in the RIS.

Comment: One commentor suggested including an action related to management of predation by and competition with nonnative species.

Response: We added action 8 to address the management of non-native species.

Comment: One commentor suggested breaking down action 9 (now action 10) into additional actions with more detail to highlight research and threats needing to be addressed sooner.

Response: One of the highest priority research needs is better genetic information on the subspecies across its range. This need is highlighted in action 5. We have added several actions to the recovery plan, based on other comments, which highlight additional, pressing research needs (e.g., competition with and predation by nonnative species). Action 9 (now action 10) will be further broken down into needed activities in the upcoming RIS.

Comment: Several commentors provided additional references for review and inclusion in the recovery plan.

Response: We have reviewed those references and included them where appropriate (e.g., the reference to Riedle et al. (2012) in action 6).