Draft 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: DRAFT
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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, and completion of recovery actions.

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RECOMMENDED CITATION AND ELECTRONIC AVAILABILITY

U.S. Fish and Wildlife Service. 2025. Draft recovery plan for Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*). U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico, USA. # pp.

An electronic copy of this Draft 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 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 soil moisture 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.

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), with the longest-lived individuals known from Quitobaquito Springs. 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 begins 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 may undergo embryonic diapause (i.e., delayed embryo development) in the nest for up to 11 months. Development begins as eggs warm during the following spring, and full development takes about 80 days. Hatchlings emerge and disperse from the nest the following year to coincide 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 has always been limited in its distribution to the Rio Sonoyta basin in Arizona and Sonora, Mexico. The subspecies was historically known from five sites in the Rio Sonoyta basin, 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 in 2019 after the sewage lagoon dried and a fire burned the site. The Sonoyta mud turtle currently occurs as one population in Arizona, and three to five populations in Sonora, Mexico (Table 1 and Figure 1).

We define 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 is thought to be unlikely (USFWS 2017, p. 24).

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, though a few turtles may be present in the remaining water and a small adjacent pond. 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). 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 Santa 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 not been visited in nearly 20 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).

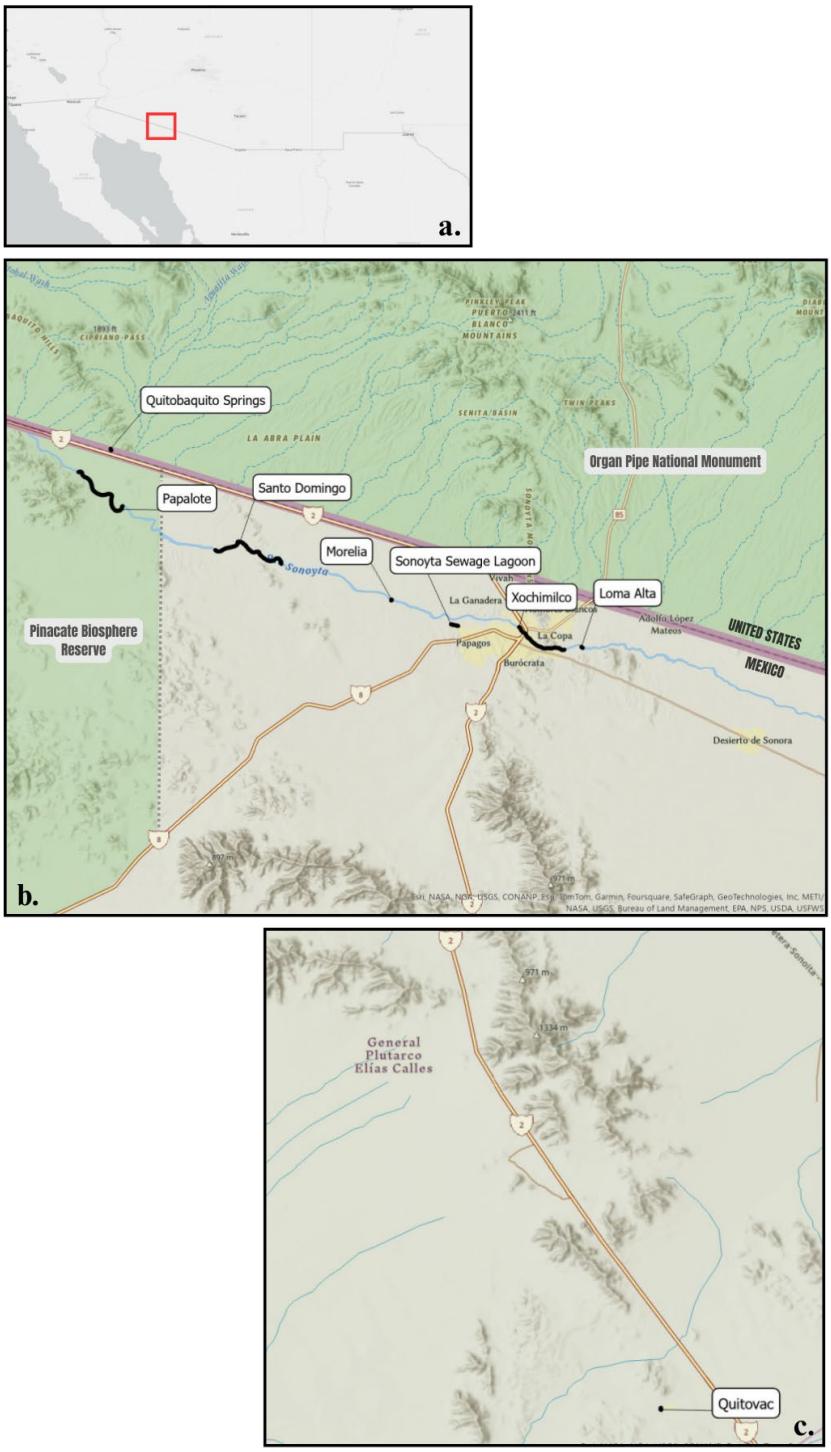

Figure 1. Current and historical range and distribution of Sonoyta mud turtle in the U.S. and Mexico. Figure 1a shows the general region where Sonoyta mud turtles are found. Figures 1b and 1c show where current and historical populations of Sonoyta mud turtle exist or previously existed on the landscape. 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.

Subpopulation	Location	Land Management	Condition in 2020 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

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 predation by and competition with nonnative species (e.g., predation by bullfrogs, crayfish, centrarchids, ictalurids, and exotic turtles and competition with black bullheads *Ameriurus melas*, African cichlid fishes [tilapia], and western mosquitofish *Gambusia affinis*), in Mexico. 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 there is sufficient habitat quantity and quality to support the long-term survival of the subspecies.

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.

Recovery 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 Sonoyta River in Sonora (e.g., Papalote, Morelia, Xochimilco, and Loma Alta); and
- At least two additional populations in the greater Sonoyta region in the U.S. or Mexico (e.g., Quitovac).

Recovery Criterion 2:
At least four populations show a stable or increasing population trend over 10 years with evidence of recruitment.

Recovery Criterion 3:
Current genetic diversity is protected and maintained across populations.

Recovery 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 10-year period:

a. Total habitat availability is maintained or increases, including water level and number of water bodies (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 six 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 Sonoyta region in the U.S. or Mexico 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 ten-year period will demonstrate population resiliency across multiple generations. If at least five 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 or 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. Connectivity and genetic diversity across populations 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 for the subspecies.

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 Act's definitions of either a threatened subspecies or endangered subspecies, and may be able to be the removed from the Federal Lists of Endangered and Threatened Wildlife and Plants.

Recovery 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 Sonoyta River in Sonora (e.g., Papalote, Morelia, Xochimilco, and Loma Alta); and
- At least three additional populations in the Sonoyta region in the U.S. or Mexico.

Recovery Criterion 2:

At least six populations show a stable or increasing population trend over 20 years with evidence of recruitment.

Recovery Criterion 3:

Current genetic diversity is protected and maintained across populations.

Recovery 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 20-year period:

a. Habitat availability is maintained or increases, including water level and number of water bodies (pools, lagoons, or river reaches); and
b. habitat and/or flow restoration efforts retain surface water in the Rio Sonoyta.

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 are managed through cooperation with local, regional, and national entities, such that Recovery 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 Sonoyta region in the U.S. or Mexico for a total of eight populations.

Justification for Recovery Criterion 2: A stable or increasing population trend over a 20-year period will demonstrate population resiliency across multiple generations 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 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 downlisting. 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 these species are known to prey upon hatchling and juvenile turtles and 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). 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.	3	3	90K
6	1	Establish and maintain two assurance populations to enhance existing populations or create new populations.	1	25	250K
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

Action #	Priority #	Site-Specific Recovery Action	Recovery Criteria	Action Duration (years)	Estimated Total Cost
8	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
9	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

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 $1,452,000 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.

7. LITERATURE CITED

Drost, C. A., J. E. Lovich, S. V. Madrak, and A. J. Monatesti. 2010. Removal of nonnative slider turtles (*Trachemys scripta*) and effects on native Sonora mud turtles (*Kinosternon sonoriense*) at Montezuma Well, Yavapai County, Arizona. U.S. Geological Survey Open-File Report 2010–1177. Available at: https://pubs.usgs.gov/of/2010/1177/

Ernst, C. H. and Lovich, J. E. 2009. Turtles of the United States and Canada. Second edition. Johns Hopkins University Press, Baltimore.

Fernandez, P. J., and P. C. Rosen. 1996. Effects of the introduced crayfish *Orconectes virilis* on native aquatic herpetofauna in Arizona. IIPAM Project I94054 Crayfish impacts on wetland herpetofauna. Heritage Program. Arizona Game and Fish Department, Phoenix Arizona.

Grageda-Garcia, M. A. 2023. Conservation status and human impacts on two endangered subspecies in the Pinacate Biosphere Reserve in Sonora, Mexico: the Sonoran pronghorn (*Antilocapra americana sonoriensis*) and the Sonoyta mud turtle (*Kinosternon sonoriense longifemorale).* Doctoral dissertation, University of Arizona, Tucson.

Hensley, F. R., T. R. Jones, M. S. Maxwell, L. J. Adams, and N. S. Nedella. 2010. Demography, terrestrial behavior, and growth of Sonora mud turtles (*Kinosternon sonoriense*) in an extreme habitat. Herpetological Monographs 24:174–193.

Paredes Aguilar, R. and P. C. Rosen. 2003. Status of the Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*) in Río Sonoyta, Mexico. Review Draft Final Report to Arizona Game and Fish Department and U.S. Fish & Wildlife Service, January 2003.

Rosen, P. C. 1986. Population decline of Sonoran mud turtles at Quitobaquito Springs. Report to U.S. National Park Service, Cooperative National Park Resources Studies Unit, University of Arizona, Tucson, Arizona.

Rosen, P. C. 2003. Taxonomic status of the Sonoyta mud turtle (*Kinosternon sonoriense longifemorale* Iverson) based on mitochondrial Dloop sequence, with a discussion of phylogeography. Unpublished report, School of Natural Resources, University of Arizona, Tucson.

Rosen, P. C. and C. H. Lowe, Jr. 1996. Population ecology of the Sonoran mud turtle (*Kinosternon sonoriense*) at Quitobaquito Springs, Organ Pipe Cactus National Monument, Arizona. Final Report to Arizona Game & Fish Dept. Heritage Program, Phoenix.

Rosen, P. C., H. W. Hermann, and C. Melendez. 2006. Phylogeography of the Southwestern mud turtle (Kinosternon sonoriense Leconte). Final report to Arizona Game and Fish Department and CONABIO (Mexico).

Stone, P. A., K. J. Locey, S. Laverty, B. D. Stanila, and M. E. B. Stone. 2015. Implications of male-biased movements in Sonoran mud turtles (*Kinosternon sonoriense*) inhabiting intermittent aquatic habitats. Herpetological Conservation and Biology 10(2):728–73.

Stone, P. A., J. D. Congdon, M. E. B. Stone, J. N. Stuart, J. B. Iverson, and P. C. Rosen. 2022. Kinosternon sonoriense (LeConte 1854)–Sonora mud turtle, desert mud turtle, Sonoyta mud turtle, Casquito de Sonora. Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs 5(119):1-22.

USFWS. 2017. Species Status Assessment Report for the Sonoyta Mud Turtle 2.0. U.S. Fish and Wildlife Service. Albuquerque, New Mexico.

van Loben Sels, R. C., J. D. Congdon, and J. T. Austin. 1997. Life history and ecology of the Sonoran mud turtle (*Kinosternon sonoriense*) in southeastern Arizona: a preliminary report. Chelonian Conservation and Biology 2:338–34.