

Recovery Plan for the Riparian Brush Rabbit
(*Sylvilagus bachmani riparius*)



Riparian brush rabbit on a trail. Photo by: Don Cool, Copyrighted, All Rights Reserved - Used by Permission, <https://www.fws.gov/media/riparian-brush-rabbit-trail>

U.S. Fish and Wildlife Service
Pacific Southwest Region 8
Sacramento, California
July 2026

Approved: _____
Regional Director, Region 8,
U.S. Fish and Wildlife Service

PURPOSE AND DISCLAIMER

This document presents the U.S. Fish and Wildlife Service's (Service) plan for the conservation of the riparian brush rabbit. The recovery plan is the second part of the Service's 3-part recovery planning framework, and includes the statutorily required elements pursuant to section 4(f) of the Endangered Species Act (Act). 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 Act and includes an analysis of the best available scientific and commercial information regarding a species' life history, biology, and current and future conditions that characterizes the species' viability (i.e., ability to sustain populations in the wild over time) and extinction risk. We have also prepared a Recovery Implementation Strategy (RIS), the third part of the framework. The RIS is an operational plan that is separate and complementary to the recovery plan. The RIS describes the on-the-ground recovery activities needed to complete the recovery actions contained in the recovery plan and is intended to be easily updated to account for changing conditions.

Recovery plans describe the envisioned recovered state for a listed species (when it should no longer meet the Act's definitions of a threatened species or endangered species) and include a recovery strategy, recovery criteria, recovery actions, and the estimates of time and cost needed to achieve it. Plans are published by the Service 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 plan formulation, other than the Service. They represent the official position of the Service 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 species status, and completion of recovery actions.

ACKNOWLEDGEMENTS

This recovery plan has benefitted from the advice and assistance of many individuals, agencies, and organizations. We thank the following individuals for their assistance and apologize to anyone whose name was omitted inadvertently from this list:

Lead Authors

Summer Howland, Sacramento Fish and Wildlife Office
Jane Spangler, Region 8– Pacific Southwest Office

Other Contributors

Collette Bradley, California Department of Parks and Recreation (CDPR)
Deana Clifford, California Department of Fish and Wildlife (CDFW)
Tristan Edgarian, US Geological Survey (USGS)
Erik Gantenbein, Center for Natural Lands Management (CNLM)
Chris Harper, San Luis National Wildlife Refuge Complex (SLNWRC)
Cathy Little, CNLM

Darren Minier, Oakland Zoo
Heather Reith, CDPR
Deborah Rogers, CNLM
Jaime Rudd, Endangered Species Recovery Program (ESRP)
Fumika Takahashi, SLNWRC

RECOMMENDED CITATION AND ELECTRONIC AVAILABILITY

U.S. Fish and Wildlife Service. 2026. Recovery Plan for riparian brush rabbit (*Sylvilagus bachmani riparius*). Pacific Southwest Region, Sacramento, California. 16 pp.

An electronic copy of this Recovery Plan will be made available at:

<https://www.fws.gov/species/riparian-brush-rabbit-sylvilagus-bachmani-riparius>

ACRONYMS

Act– Endangered Species Act

CDFW– California Department of Fish and Wildlife

CDPR– California Department of Parks and Recreation

CNLM– Center for Natural Lands Management

CMSP– Caswell Memorial State Park

ESRP– California State University Endangered Species Recovery Program

RIS– Recovery Implementation Strategy

Service– U.S. Fish and Wildlife Service

SJRNWR– San Joaquin River National Wildlife Refuge

SJRFCPA– San Joaquin River Flood Control Protection Agency

SSA– Species Status Assessment

USGS– U.S. Geological Survey

1. INTRODUCTION

This recovery plan describes criteria for determining when the riparian brush rabbit 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 species' 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 riparian brush rabbit can be found in the Species Status Assessment (SSA). Detailed on the ground activities implementing recovery actions can be found in the Recovery Implementation Strategy (RIS). These supplemental documents are available at <https://www.fws.gov/species/riparian-brush-rabbit-sylvilagus-bachmani-riparius>. The RIS and SSA are finalized separately from the Recovery Plan and will be updated on a routine basis.

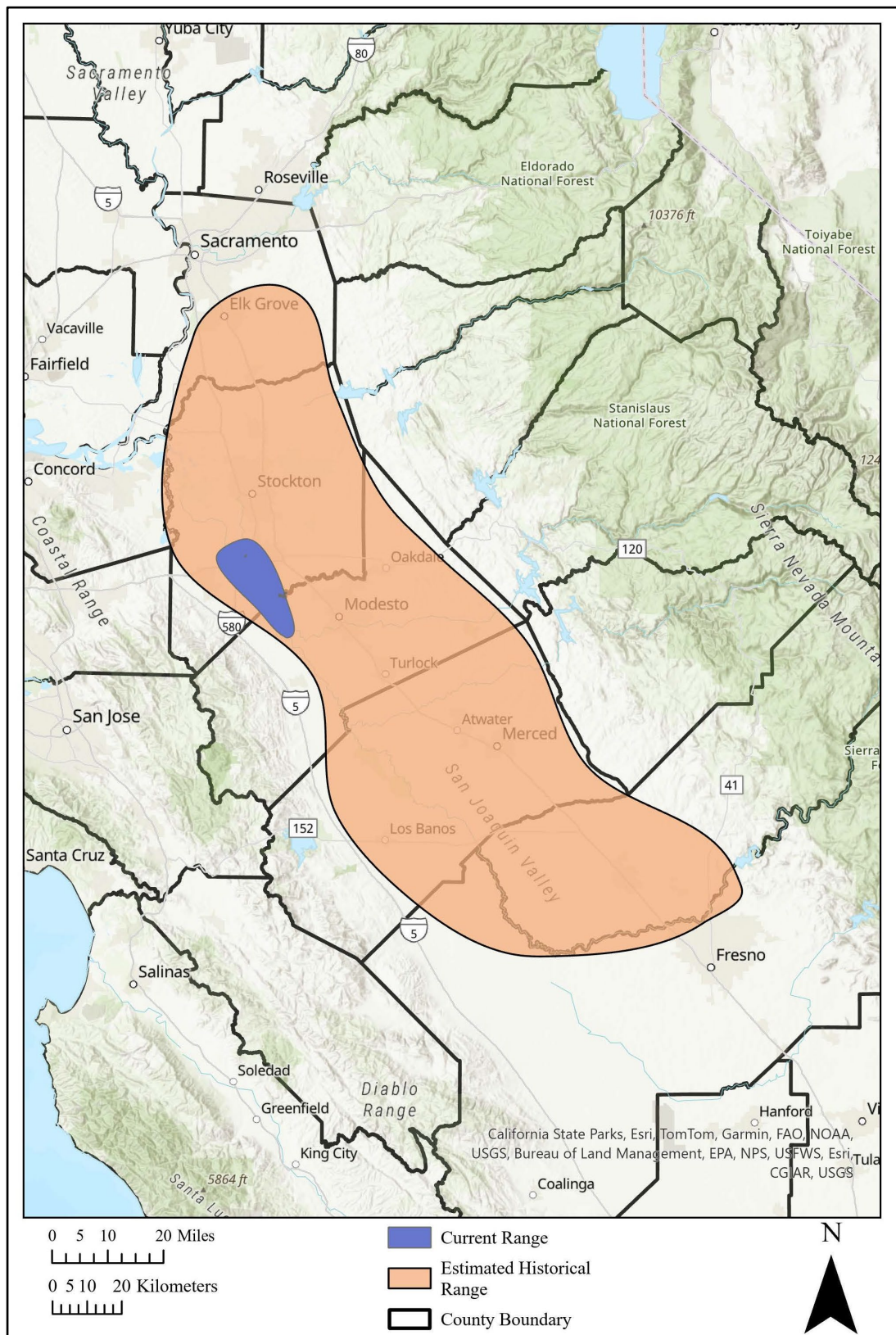
2. SUMMARY OF SPECIES STATUS ASSESSMENT

Riparian brush rabbits (*Sylvilagus bachmani riparius*) are a subspecies of brush rabbit endemic to the San Joaquin Valley of California (Service 2020, pp. 11–12). The subspecies was first protected under the California Endangered Species Act in 1994 and in 2000 was listed as endangered under the Act (65 FR 8881–8890). The subspecies is facing many of the same threats that warranted their State and Federal listings, including loss and degradation of habitat, flooding, predation, drought, wildfire, and disease (Service 2020, pp. 47, 62). Figure 1 below shows the subspecies' estimated historical range before land conversions in the early 1900s and the current range that has been severely contracted over time (Service 2020, p. 13).

The subspecies currently occupies a limited range with only three known populations throughout northern Stanislaus County and southern San Joaquin County in California (Service 2020, p. 11). Historically, the subspecies was likely found in Merced County; however, there are not currently any known populations in this county (Service 2020, p. 11). The riparian brush rabbit is currently found at the San Joaquin River National Wildlife Refuge (SJRNWR), Caswell Memorial State Park (CMSP), and a patch of mostly private lands called South Delta that contains the Oxbow Preserve, an area specifically managed for riparian brush rabbit. The Oxbow Preserve is treated separately from the rest of the South Delta population in the SSA for a variety of reasons, including that the Oxbow Preserve population has become genetically isolated from the rest of the South Delta population and the fact that the Oxbow Preserve is the only habitat in the South Delta with conservation protections (Matocq *et al.* 2017, p. 22; Service 2020, p. 11).

The riparian brush rabbits' habitat needs are not fully understood, but they include patches of dense, brushy vegetation for cover and nesting that are adjacent to open areas to allow access to grasses and herbs for foraging and collection of nesting materials (Service 2020, pp. 23–24). Additionally, the subspecies needs high ground refugia with a diversity of food resources and dense cover to retreat to during flood events, ideally with scaffolding trees to provide support for food resources to grow above flood water lines (Service 2020, p. 25). Riparian brush rabbits also require ecotonal edges with forage next to cover and a diversity of plant life that includes species that are drought or flood tolerant (Service 2020, pp. 24–25). Finally, they need to be connected through corridors of brush patches to disperse, migrate, and to access to refugia during stochastic events (Service 2020, pp. 27, 31).

Figure 1. Riparian brush rabbit estimated historical and current range. The estimated historical range is a coarse representation of a potential historical distribution based on pre-1900 land cover (California State University Chico 2003, spatial dataset). The current range is based on occurrence point data that were aggregated into a polygon and smoothed with Bezier interpolation [Smooth Polygon ArcGIS tool (Esri 2018)].



Threats to the riparian brush rabbit are varied but have largely remained the same since the time of federal listing. One threat that has severely impacted the subspecies is habitat loss and degradation through land conversion for commercial, residential, and agricultural development (Thompson 1961, pp. 311–313). These changes have also affected hydrology throughout the riparian brush rabbit range and have contributed to increasing the severity of flood events (Close and Williams 1998, p. 1). Flooding affects riparian brush rabbits not only through direct mortality from drowning, but also indirectly by leading to starvation or predation (Kelly *et al.* 2013, p. 5).

Wildfire and drought are also causes of indirect and direct mortality. While small wildfires can be beneficial, fire suppression activities have led, in part, to larger and more destructive modern fires (Service 2020, p. 38). Riparian brush rabbits can be killed directly by fire, but also by running to fire breaks that eventually burn, being run over by firefighting equipment, through starvation when forage is no longer available, or increased predation due to exposure (Service 2020, p. 38). During droughts, the availability of cover and forage can drastically decrease, leading to starvation, increased predation due to exposure, and a decrease in abundance that can be difficult to rebound from, especially during prolonged droughts (Larsen 1993, p. 13).

Disease and predation have also been indicated as threats to the subspecies. While disease is a concern, especially after the detection of rabbit hemorrhagic disease virus 2 (RHDV2) in riparian brush rabbits, there is less known about the effect that emerging diseases could have on the small populations of this subspecies (Russell *et al.* 2024, p. 3). Predation is a known threat to the riparian brush rabbit, and is considered the second leading cause of mortality after flooding (Williams *et al.* 2008, p. 357). Predators on the landscape are known and varied, ranging from native species, like coyote (*Canis latrans*) and great-horned owl (*Bubo virginianus*), to invasives, such as domestic cats (*Felis catus*) and black rats (*Rattus rattus*) (Kelly *et al.* 2011, p. 6).

The subspecies' needs, current condition, and future condition were evaluated and summarized in the SSA report as they relate to resiliency, redundancy, and representation (Service 2020, entire). The population needs considered in the report were abundance, reproduction and recruitment, survival, distribution, and large-scale connectivity (Service 2020, pp. 27–31). Currently, riparian brush rabbit viability is low, but with increased conservation efforts there is the potential for recovery (Service 2020, p. 3).

3. RECOVERY STRATEGY

The recovery strategy provides a concise overview of the envisioned recovered state for riparian brush rabbit, describes the Service'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 (*e.g.*, recovery criteria, recovery actions, and estimates of time and cost) will work together to achieve riparian brush rabbit's recovery.

The recovery strategy for the riparian brush rabbit is to increase the resiliency, redundancy, and representation of the subspecies through recovery actions that lead to self-sustaining populations throughout the historical range. The riparian brush rabbit is constrained by habitat loss and degradation, flooding, wildfire, vegetation management issues, forest succession, disease, predation, and changing climatic conditions. Conservation efforts are needed into the foreseeable future to improve viability. The recovery of the riparian brush rabbit will incorporate

conservation efforts that restore, enhance, expand, and conserve large patches of quality habitat. Areas with ecotonal edges, high-ground flood refugia, adequate forage, and dense, brushy vegetation will be prioritized before focusing on areas that require restoration. The populations will be spread throughout the range with connectivity achieved through vegetated corridors to promote gene flow. The abundance per population will be large enough to withstand environmental stochasticity throughout time even while dealing with gaps in knowledge, particularly those associated with climate change.

Partnerships and collaboration will be vital for the recovery of riparian brush rabbit. These relationships have already been vital in our understanding of riparian brush rabbit life history, habitat restoration projects, and threat assessments for the subspecies. While the scope of collaboration will depend on the entities involved and the questions being asked, some of the activities will include restoration of riparian habitat on private lands, working to form a genetic management plan, development of standardized survey protocols, emerging disease vaccination programs, and habitat suitability and flood modeling. There are and will be many partners involved in the recovery of the riparian brush rabbit, including but not limited to CDFW, CDPR, ESRP, USGS, the Fresno Chaffee Zoo, the Oakland Zoo, River Partners, CNLM, and Tribal communities. As we continue to gain a better understanding of the needs associated with self-sustaining populations of riparian brush rabbit, it will be necessary to make changes to our approach through regular checkpoints that allow us to adaptively manage the subspecies.

4. RECOVERY CRITERIA

Recovery criteria are statutorily required objective, measurable descriptions of a recovered state for riparian brush rabbit, as described in [4\(f\)\(1\)\(b\)\(ii\)](#) of the Act. Recovery criteria describe the conditions of resiliency, redundancy, representation, and threat abatement that indicate when riparian brush rabbit may no longer meet the Act's definitions of an endangered species or threatened species. Recovery criteria present our best estimate of a species' recovered condition at the time of recovery plan development. Changes in available information, technologies, and our understanding of the subspecies over time might mean that the recovered state envisioned by the recovery criteria differs from our assessment in a later status determination.

Downlisting Criteria

The following downlisting criteria, when met collectively, would indicate that the riparian brush rabbit may be reclassified as a threatened species.

Criterion 1: The distribution over a fifteen-year period indicates there are at least five populations of riparian brush rabbit. The populations are spread across their estimated historical range with population trends that are stable or increasing over the monitoring period described. These five populations have a moderate number of individuals as defined in the SSA which is documented through standardized survey methods.

Criterion Rationale:

For this criterion, we chose a time period of fifteen years because this is likely to include at least one major flood event. Between 1950–2023, there have been at least fourteen major flood events in the South Delta and lower San Joaquin River which have had direct and indirect impacts on riparian brush rabbit populations and their habitat (SJRFCA 2015, pp. 2-10–2-13; CDFW 2020, p. 14). In the SSA, flooding in the San Joaquin Valley is noted to regularly occur and acts as a

major stressor to riparian brush rabbit populations, both directly and indirectly (SJRFPCA 2015, pp. 2-10–2-13; Service 2020, pp. 36–37). Based on climate change models, intense precipitation events are expected to increase in the San Joaquin Valley and will likely lead to an increase in major flooding events (Service 2020, p. 36; Fernandez-Bou *et al.* 2021, p. 17). For riparian brush rabbits, flooding can lead to drowning but the impact is exacerbated by the lack of high-water refugia on leveled land, lack of suitable habitat and forage on levee banks, insufficient connectivity to other areas to allow escape during high-water events, and land subsidence extending the duration of flood events (Service 2020, pp. 36–37). Rabbits that do make it to high ground then become susceptible to starvation and predation, especially in the prolonged seasonal floods (Williams 1988, p. 4; Kelly *et al.* 2013, p. 5). Lastly, floods damage riparian habitat by scouring vegetative cover and forage plants and killing vegetation intolerant of prolonged inundation such as coyote bush (*Baccharis pilularis*), blue elderberry (*Sambucus mexicana*), California rose (*Rosa californica*), and California blackberry (*Rubus ursinus*) (River Partners 2008, p. 17). Therefore, a timeline of fifteen years related to flooding cycles provides an adequate time period to track trends in riparian brush rabbit populations and would capture population responses following at least one significant flood event.

When there are at least five populations spread across the historical range this will provide a buffer during catastrophic or stochastic events that can ensure the subspecies persists into the future. For this recovery plan we are using the definition of a population from the SSA which defines a population as a spatially congruent group of individuals (or groups of patches of individuals) that are distinct from each other because of genetic differentiation, spatial isolation, and/or separation by barrier(s) over which genetic exchange is infrequent. The South Delta and CMSP populations are the only known extant natural riparian brush rabbit populations. Together, these populations harbor most of the genetic diversity left within the subspecies and the associated adaptive capacity, with a high degree of genetic differentiation and minimal overlap of individuals between populations (Matocq *et al.* 2017, pp. 7, 21–22; Service 2020, p. 32). These extant natural populations are also the source of much of our knowledge regarding the ecology of the subspecies, which has been used to create protocols and inform management of the species. As a result, the continued existence of these extant natural populations will be important for the recovery of the subspecies and should be prioritized when making management decisions.

Criterion 2: Flood refugia are in high condition (as defined in the SSA) for each population in Downlisting Criterion 1 with adequate food and shelter available and access provided to refugia through habitat corridors. The lands containing the flood refugia are fully protected through fee ownership by a resource agency or conservation program, conservation easement, or other durable means of permanent protection with adequate funding in place.

Criterion Rationale:

The detrimental effects of flooding on riparian brush rabbits have been increasing and are projected to continue to increase due, in part, to climate change, habitat loss, and habitat degradation (Service 2020, p. 37). Riparian habitat restoration projects currently being designed and implemented include the goal of providing approximately 5% of restored lands as high-ground flood refugia to decrease the probability of flood induced mortality (Service 2020, p. 51). However, 5% has not been adequate to reduce mortality. Therefore, this criterion states that

flood refugia are in high condition, which ensures that $\geq 10\%$ of habitat is found on high ground, with ample food and cover.

Criterion 3: Populations described in Downlisting Criterion 1 have connectivity to at least one other population and/or have potential for population expansion into adjacent unoccupied suitable habitat.

Criterion Rationale:

The current extant populations of riparian brush rabbit are isolated due in part to habitat fragmentation, which has led to genetic drift and the potential loss of adaptive capacity (Matocq *et al.* 2017, p. 21). Habitat corridors can increase genetic diversity among populations by providing opportunities for individuals to disperse into adjacent occupied habitat and adjacent unoccupied suitable habitat, potentially forming new populations. Habitat corridors are considered a network of brush patches, small bushy trees, or other low or mid-height vegetation such as dense grasses, sedges, or other herbaceous plants, that are connected by corridors or continuous cover with only short gaps between cover, as riparian brush rabbits rarely venture more than 1–2 meters from cover (Chapman 1974, p. 3; Service 2020, p. 27). Due to the far distances between populations, the need for habitat islands along dispersal corridors that connect populations may be appropriate and will need to be determined by wildlife managers during restoration activities.

Criterion 4: Effective management ensures that pathogen prevalence and disease incidence are minimized such that there are not population-level impacts.

Criterion Rationale:

While the rates of infection for specific pathogens and diseases within riparian brush rabbit populations are unknown, rabbit hemorrhagic disease virus serotype-2 (RHDV2) has become an increasing concern since 2020. However, recent models indicate that vaccination of even 30% of a riparian brush rabbit population could decrease mortality significantly and provide the time for other important recovery actions to take place (Russel *et al.* 2024, p. 9). The efficacy of the management actions can be informed by surveys referenced in Downlisting Criterion 1.

Criterion 5: Effective management ensures that non-native predation is minimized such that there are not population-level impacts.

Criterion Rationale:

After flooding, predation is the second leading cause of mortality for riparian brush rabbits (Service 2020, p. 43). In a monitoring study of translocated riparian brush rabbits, predation had the greatest known impact on survival of the translocated individuals (Hamilton *et al.* 2010, p. 1002). Both extant natural populations are at risk of predation, and with low abundance, this threat could lead to extinction without conservation measures in place (Williams *et al.* 2002, pp. 1, 12). Non-native predators include domestic pets and black rats, which have specifically been noted to predate on riparian brush rabbit neonates (Service 2020, p. 43). The efficacy of the management actions can be informed by surveys referenced in Downlisting Criterion 1.

Delisting Criteria

The following delisting criteria, when met collectively, may indicate that the riparian brush rabbit no longer meets the Act's definitions of either a threatened species or endangered species,

and may be able to be removed from the Federal Lists of Endangered and Threatened Wildlife and Plants.

Criterion 1: Delisting Criterion 1 is met when Downlisting Criteria 1 is satisfied and at least two of the five populations described for Downlisting Criterion 1 have high abundance, while the remainder have at least moderate abundance (as defined in the SSA), documented through standardized survey methods over a fifteen-year period.

Criterion Rationale:

The primary threats to the subspecies, including flooding, wildfire, and disease, are expected to worsen in the future and are likely to continue to affect all populations, especially because the populations are all in close proximity to one another. High and moderate abundance can provide populations with a buffer to extirpation when they are being impacted by threats. The SSA currently defines moderate abundance as 200–500 individuals and high abundance as ≥ 500 individuals (Service 2020, p. 53). High abundance is feasible as abundance estimates from SJRNWR have regularly been over 1,000 individuals. Therefore, an increase to high abundance for at least two populations is attainable and necessary to prevent the subspecies from becoming endangered in the foreseeable future.

Criterion 2: For each population addressed in Delisting Criterion 1, habitat is managed to ensure the habitat features identified in the SSA (quantity, quality, and refugia) are accessible and in high condition (as defined in the SSA) to the extent that the associated population of riparian brush rabbits can withstand environmental stochasticity including catastrophic flooding, wildfire, and disease episodes. Durable agreements are in place to ensure such management will continue into the foreseeable future.

Criterion Rationale:

Habitat suitability/quality scores of ≥ 2.5 indicate healthy habitat for riparian brush rabbits (Service 2020, p. 53). This scoring system is based on a habitat suitability model, qualitative and/or quantitative habitat descriptions to validate the results of the model, and/or adjustments to the model based on limitations (Phillips *et al.* 2013, entire).

Criterion 3: For each population addressed in Delisting Criterion 1, habitat sufficient in area to support the population is fully protected through fee ownership by a resource agency or conservation program, conservation easement, or other means of permanent protection with adequate funding in place.

Criterion Rationale:

The area needed to support populations of riparian brush rabbit is not fully understood. While there have been at least two studies on home ranges, these were biased by trap design, sample size, or the fact that native rabbits were introduced to restored habitat (Basey 1990, pp. 74–75; Kelt *et al.* 2014, pp. 521–522). The decision for the SSA was to use observation from the first study, with home range size from 0.02 hectare (0.06 acre) to 0.10 hectare (0.24 acre) (Basey 1990, pp. 74–75). However, the second study indicated much larger home ranges, and more research is needed to understand what area of habitat a population needs.

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 Act. The Service 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 implies 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 species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline in species 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 species.

The following actions will aid in the recovery of the riparian brush rabbit. However, these actions may not be feasible for every population, may lack funding or staffing resources, and will require collaboration. These factors need to be taken into consideration while balancing the fact that riparian brush rabbit is endangered and in need of conservation efforts to aid in recovery.

1. Implement range wide inventory and monitoring of riparian brush rabbit populations and habitat to support recovery efforts. (Priority 1)

Additional Information: Regular monitoring of population demographics and habitat condition is important to appropriately manage a species in need of recovery. To gain a better understanding of riparian brush rabbit response to recovery activities and stressors it is necessary to conduct standardized surveys across populations and preserved habitats throughout the range. Monitoring on private lands, specifically the South Delta population, could include coordination with Farm Bureaus and the San Joaquin Local Agency Formation Commission.

2. Increase the number of resilient riparian brush rabbit populations to the extent possible within suitable habitats throughout the historical range to increase species' viability. (Priority 1)

Additional Information: There are few extant riparian brush rabbit populations and they have low abundances, which increases their susceptibility to extirpation. Increasing the number of resilient populations of riparian brush rabbit can help the subspecies to persist into the future when catastrophic events occur by spreading the populations across the landscape, so they are not equally affected by an individual event.

3. Identify and evaluate the magnitude of existing stressors and sources of threats throughout the species range (e.g., flooding, disease, drought, predation, competition, etc.) and manage for their abatement. (Priority 1)

Additional Information: Understanding the magnitude of existing and emerging threats to riparian brush rabbit can lead to a proactive approach when addressing these issues.

4. Conserve, restore, and permanently protect occupied habitat throughout the species' range. (Priority 1)

Additional Information: Because the species only has a few populations that also have low abundances, it's vital that we protect the resources that these populations need to persist into the foreseeable future.

5. Conserve, restore, and permanently protect unoccupied suitable habitat, including high ground refugia and habitat corridors, throughout the species' range. (Priority 2)

Additional Information: One of the primary threats to riparian brush rabbits is the destruction and modification of their habitat which has impeded dispersal, restricted population sizes, and ultimately hindered the recovery of the subspecies. By restoring and protecting suitable habitat, especially habitat adjacent to extant populations, we provide a mechanism for dispersal, recolonization, and re-introductions.

6. Identify, prioritize, and conduct research to inform management actions where appropriate throughout the range of the species. (Priority 2)

Additional Information: There are still many gaps in knowledge about the riparian brush rabbit that are necessary to effectively recover and manage the subspecies. At present, there are many life history requirements that are unknown, including home range size and food preferences, that can make it difficult to know what to prioritize for the subspecies.

7. Conduct field surveys throughout the range to potentially locate undiscovered populations. (Priority 3)

Additional Information: Riparian brush rabbit populations may exist outside of the three known populations. However, surveys are necessary to discover any remanent or dispersed populations that may exist.

8. Initiate outreach opportunities to improve awareness and gain support for conservation efforts and provide education/educational materials to the public throughout the species' range. (Priority 3)

Additional Information: Educational materials and resources are important for information sharing with the public regarding the subspecies and its recovery but can also be important when working with programs and organizations such as wildland firefighting, Resource Conservation Districts, Farm Bureaus, private landowners, and other landowner-focused groups. The support of the public will be especially important in the recovery of the subspecies since much of the land within their historical range is privately owned.

Table 1. Threats summary table. Endangered Species Act listing factor abbreviations described below are habitat loss and degradation (A), disease or predation (C), and other natural or manmade factors affecting the species continued existence (E). The listing factor for the over-utilization of the species for commercial, recreational, scientific, or educational purposes (B) is not currently a threat to this species and therefore is not included in the table.

Listing Factor	Threat Description	Downlisting Criteria	Delisting Criteria	Recovery Actions
Factor A The present or threatened destruction, modification, or curtailment of its habitat or range	- Habitat loss/degradation	2– Flood refugia in high condition and protected 3– Habitat connectivity	2– Habitat management 3– Habitat protection	2– Increase number of populations across historical range 4– Restore and protect occupied habitat 5– Restore and protect unoccupied habitat 7– Survey throughout historical range 8– Outreach and education
Factor C Disease or predation	- Disease - Predation	1– Five populations in moderate condition, stable or increasing 4– Disease is not influencing demography 5– Predation is not influencing demography	1– Two populations in high and three populations in moderation condition, stable or increasing	1– Inventory and monitor populations for demography trends 3– Identify, evaluate, and abate stressors 6– Research
Factor E Other natural or manmade factors affecting its continued existence	- Fragmented populations - Wildfire - Flooding - Drought - Climate Change	1– Five populations in moderate condition, stable or increasing 2– Flood refugia in high condition and protected 3– Habitat connectivity	1– Two populations in high and three populations in moderation condition, stable or increasing 2– Habitat management 3– Habitat protection	2– Increase number of populations across historical range 3– Identify, evaluate, and abate stressors 4– Restore and protect occupied habitat 5– Restore and protect unoccupied habitat 6– Research 7– Survey throughout historical range

6. ESTIMATED TIME AND COSTS TO ACHIEVE RECOVERY

Estimates of time and cost, as defined in section [4\(f\)\(1\)\(B\)\(iii\)](#) of the Act, must reflect, to the maximum extent practicable, the total amount of time and costs it will take to achieve the recovery (delisting) of riparian brush rabbit. 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 riparian brush rabbit so that it could be delisted following the adoption of this recovery plan and cost approximately \$150,959,900, which is summarized in Table 2 below. The costs include financial, volunteer, and in-kind support as well as other conservation endeavors likely to be supported by other cooperating agencies.

We estimate that completion of these actions could lead to delisting in 30 years after suitable habitat for five populations is secured and protected. This time frame allows for management of occupied habitat as well as captive rearing and translocation as needed to supplement existing populations or establish new populations in protected suitable habitat. However, we acknowledge that the initial steps to secure land protection will not be instantaneous, thus adding an unknown number of years towards recovery for this subspecies.

We note that the recovery program may change over time, or the timeframe estimated to implement the recovery actions to achieve recovery of the species may take longer than expected. The recovery of riparian brush rabbit will depend largely on the commitment and the ability of the Service and partners to implement the recovery actions necessary to achieve the recovery criteria.

Table 2. Riparian brush rabbit recovery actions and estimated costs.

Recovery Action Number	Summary of Recovery Action	Estimated Time to Achieve (years)	Estimated Cost
1	Range wide surveys and monitoring	15	\$2,775,000
2	Increase number of populations throughout range	15–30	\$43,310,000
3	Identify, evaluate, and abate stressors	15	\$8,200,000
4	Conserve, restore, and protect occupied habitat	30	\$8,100,000
5	Conserve, restore, and protect unoccupied habitat	30	\$70,480,000
6	Conduct research to inform management and conservation actions	15	\$6,825,000
7	Conduct presence/absence surveys throughout historical range	15	\$10,725,000
8	Outreach and education	5	\$544,900
Estimated Total Cost to Recovery			\$150,959,900

Literature Cited

- Basey, G.E. 1990. Distribution, ecology, and population status of the riparian brush rabbit (*Sylvilagus bachmani riparius*). M.S. Thesis. California State University, Stanislaus. Pp. 1–76.
- California State University Chico. 2003. Historic vegetation base map (pre-1900). Spatial dataset.
- [CDFW] California Department of Fish and Wildlife. 2020. Five-year status review of riparian brush rabbit (*Sylvilagus bachmani riparius*). Report to the Fish and Game Commission. Pp. 1–46.
- Chapman, J.A. and J.A. Litvaitis. 2003. Eastern cottontail: *Sylvilagus floridanus* and allies. In: *Wild Mammals of North America* (Ed. by G.A. Feldhammer, B.C. Thompson and J.A. Chapman). Johns Hopkins University Press, Baltimore, Maryland. Pp. 101–125.
- Close, C.L., and D.F. Williams. 1998. Habitat management for riparian brush rabbits and woodrats with special attention to fire and flood. Endangered Species Recovery Program, California State University, Stanislaus. Pp. 1–50.
- Fernandez-Bou, A.S., Ortiz-Partida, J.P., Pells, C., Classen-Rodriguez, L.M., Espinoza, V., Rodríguez-Flores, J.M., and J. Medellín-Azuara. 2021. Regional Report for the San Joaquin Valley Region on Impacts of Climate Change. California Natural Resources Agency. Pp. 1–99.
- Hamilton, L.P., Kelly, P.A., Williams, D.F., Kelt, D.A., and H.U. Wittmer. 2010. Factors associated with survival of reintroduced riparian brush rabbits in California. *Biological Conservation* 143:999–1007.
- Kelly, P.A., Edgarian, T.K., Lloyd, M.R., and S.E. Phillips. 2011. Conservation principles for the riparian brush rabbit and riparian woodrat. California State University, Stanislaus. Pp. 1–8.
- Kelly, P.A., Edgarian, T., and F. Cannizzo. 2013. Controlled propagation and release of riparian brush rabbits in the northern San Joaquin Valley, California (8 June 2011 – 31 December 2012), final report. California State University, Stanislaus. Pp. 1–22.
- Kelt, D.A., Kelly, P.A., Phillips, S.E., and D.F. Williams. 2014. Home range size and habitat selection of reintroduced *Sylvilagus bachmani riparius*. *Journal of Mammalogy* 95(3):516–524.
- Larsen, C.J. 1993. Status review of the riparian brush rabbit (*Sylvilagus bachmani Riparius*) in California. California Department of Fish and Game [Wildlife]. Pp. 1–23.

- Matocq, M., Kelly, P., Rippert, J., and S. Phillips. 2017. Population genetic structure of the riparian brush rabbit (*Sylvilagus bachmani riparius*): using multiple marker systems to gain insight into historic and ongoing genetic connectivity. University of Nevada, Reno and California State University, Stanislaus. Pp. 1–41.
- Phillips, S.E., Edgarian, T.K., Lloyd, M.R. and P.A. Kelly. 2013. Habitat suitability and connectivity for riparian brush rabbits in the northern San Joaquin Valley and Sacramento/San Joaquin River Delta. California State University, Stanislaus. Pp. 1–36.
- River Partners. 2008. Effects of long duration flooding on riparian plant species in restoration plantings. San Joaquin River National Wildlife Refuge, Stanislaus County, California. Pp. 1–25.
- Russel, R.E., Dusek, R.J., Prevost, S., Clifford, D.L., Moriarty, M.E., and F. Takahashi. 2023. Modeling the response of an endangered rabbit population to RHDV2 and vaccination. *Conservation Science and Practice* 6(2):1–13.
- [Service] U.S. Fish and Wildlife Service. 2020. Species Status Assessment for the Riparian Brush Rabbit (*Sylvilagus bachmani riparius*), Version 1.0. Pacific Southwest Region, Sacramento, California. Pp. 1–109.
- [SJRFPCA] San Joaquin River Flood Control Project Agency. 2015. Final: Upper San Joaquin River Regional Flood Management Plan. Pp. 1-1–9-6.
- Takahashi, F.D. 2022. San Joaquin River National Wildlife Refuge and the endangered riparian brush rabbit. PowerPoint presentation presented on Zoom to the California Naturalist Program, February 10, 2022.
- Thompson, K. 1961. Riparian forests of the Sacramento Valley, California. *Annals of the Association of American Geographers* 51:294–315.
- Williams, D., Kelly, P., Hamilton, L., Lloyd, M., Williams, E., and J. Youngblom. 2008. Recovering the endangered riparian brush rabbit (*Sylvilagus bachmani riparius*): Reproduction and growth in confinement and survival after translocation. In: *Lagomorph Biology*, Springer Berlin Heidelberg, Berlin, Heidelberg. Pp. 349–361.
- Williams, D.F. and L.P. Hamilton. 2002. Riparian brush rabbit survey: Paradise Cut along Stewart Tract, San Joaquin County, California, August 2001. Pp. 1–10.
- Williams, D.F. 1988. Ecology and management of the riparian brush rabbit in Caswell Memorial State Park. California State University, Stanislaus. Pp. 1–31.