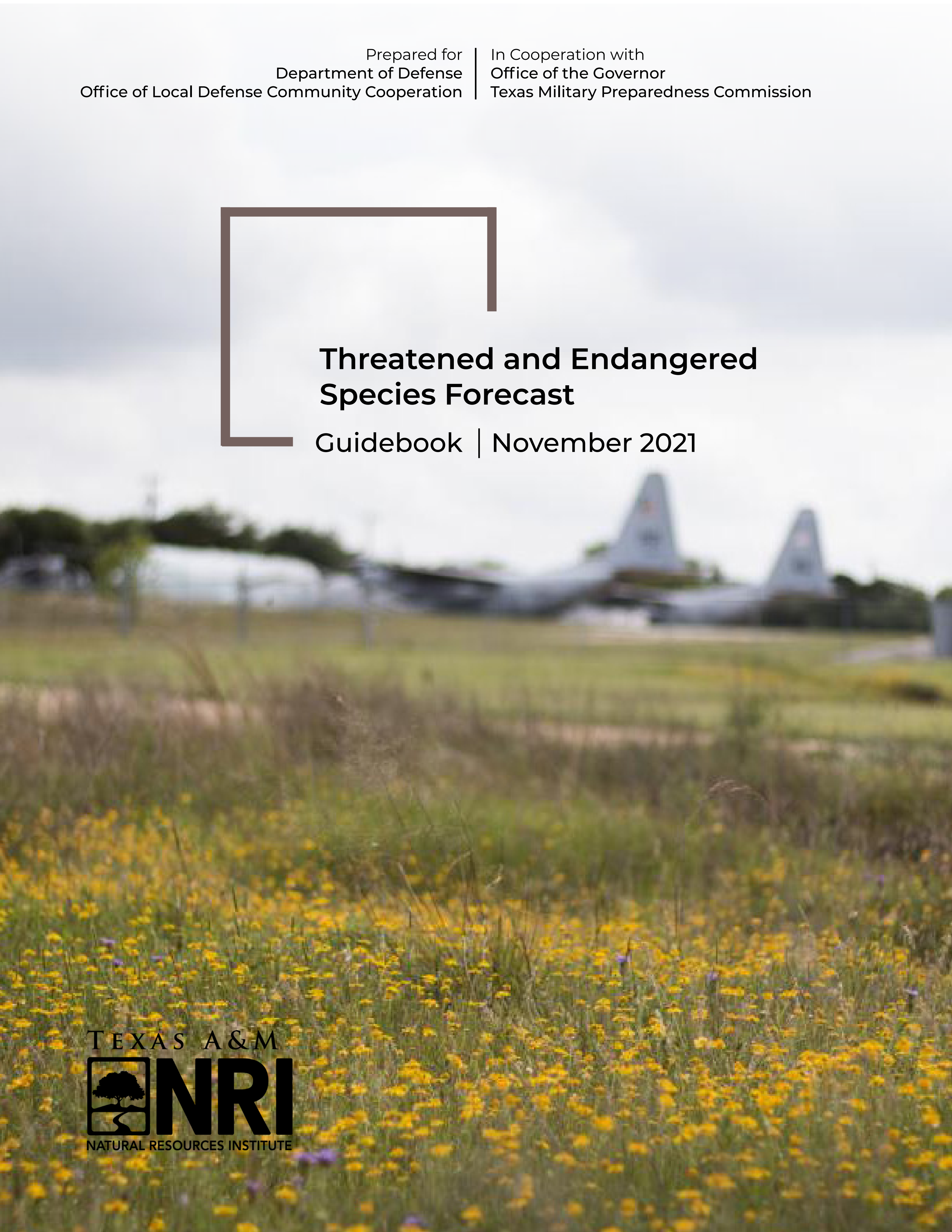
Prepared for
Department of Defense
Office of Local Defense Community Cooperation

In Cooperation with
Office of the Governor
Texas Military Preparedness Commission

# Threatened and Endangered Species Forecast

Guidebook | November 2021



Texas A&M NRI
Natural Resources Institute

# Background

*“Plans to protect air and water, wilderness and wildlife are in fact plans to protect man.” —Stewart Udall*

## PREVIOUS WORK

The military mission, while imperative to national defense, is under mounting pressure from various encroachment and incompatible land use threats. These threats include any outside activity, law, or pressure that affects the ability of military forces to train to doctrinal standards or to perform the mission assigned to the installation. In an effort to reduce land use conflict spurring from energy development, the Texas A&M Natural Resources Institute (NRI), in partnership with the Texas Military Preparedness Commission (TMPC), and with a grant from the Department of Defense (DoD) Office of Local Defense Community Cooperation (OLDCC; formerly the Office of Economic Adjustment), developed the Texas Early Notification Tool—a web mapping application that facilitates early engagement between developers (mainly wind industry) and the military.

Expanding on this work, NRI obtained a follow-on grant in 2020 from the OLDCC to continue addressing land use compatibility issues affecting Texas installations. The project, titled *Protecting Military Readiness in Texas: Phase II*, includes four tasks uniquely designed to address key aspects of impacts to military assets. As part of that effort, this guidebook serves to assist installation natural resource managers in forecasting potential new threatened and endangered species listings for species that may occur on military installations in Texas.

## SPECIES PROTECTION

The federal government owns 640 million acres of land in the U.S., including 25 million acres of biologically diverse landscapes that fall under the jurisdiction and management of the DoD. The importance of DoD lands to sustainable wildlife populations and their unique habitats is well established, especially for species of conservation concern.[1] A 2014 assessment report concluded that 458 federally listed threatened and endangered species and 555 at-risk species occur across military defense sites, and more than 40 of these species are found exclusively on DoD land.[2] A multitude of federal, state, and local laws and regulations provide the legal framework for conservation and management of the natural resources on federal lands.

## NEW TOOL

The Sikes Act Improvement Act of 1997 (PL 105-85) specifically requires military facilities to prepare an Integrated Natural Resources Management Plan (INRMP) in cooperation with local fish and wildlife agencies. The INRMP provides a framework for conservation and management that meets natural resource requirements while maintaining the military mission. While an INRMP serves as a guiding document for natural resource managers, supplemental information about species that face potential listing as threatened or endangered (T&E) would be beneficial. This information can provide the necessary background for managers to proactively plan for the effective monitoring and management of T&E species in light of funding constraints and critical mission planning.

[1]Stein B.A., C. Scott, and N. Benton. 2008. Federal lands and endangered species: the role of military and other federal lands in sustaining biodiversity. BioScience 58:4.

[2]NatureServe. 2015. Species at risk on Department of Defense lands: 2014 updated analysis, report, and maps. Report prepared for US Department of Defense.

# Guidebook

The purpose of this guide is to provide a snapshot of species that could potentially be listed as threatened or endangered under the U.S. Endangered Species Act (ESA) in the near future, and that may occur on military installations in Texas. It is important to note that other species not included in this guide could be listed and U.S. Fish and Wildlife Service (USFWS) may not meet their projected timelines for listing decisions.

To determine which species to include, we first consulted Texas Parks and Wildlife Department's (TPWD) Rare, Threatened, and Endangered Species of Texas database, USFWS's Environmental Conservation Online System, and the USFWS 5-Year National Listing Workplan. We then elicited input from NRI's wildlife research scientist team to finalize the species list. Using county-level data, we determined which installations fall within each of those species' ranges.

The following section describes the identified species through *Species Account* sheets, which summarize pertinent information needed for managers to get started in the planning process. The installation reference table identifies species that fall within each installation's footprint, including annexes and auxiliary and outlying fields, and linked page numbers to the associated Species Account sheets. The Species Account sheets are grouped by taxon in the following pages.

## DATA SOURCES

*All data was obtained in January 2021.*

TPWD Rare, Threatened, and Endangered Species of Texas database:
https://tpwd.texas.gov/gis/rtest/

USFWS Environmental Conservation Online System:
https://ecos.fws.gov/ecp/

USFWS 5-Year National Listing Workplan:
https://www.fws.gov/endangered/esa-library/pdf/5-Year%20Listing%20Workplan%20May%20Version.pdf

## INSTALLATION REFERENCE TABLE

| Installation | Species | Page |
|---|---|---|
| Dyess Air Force Base | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Perimyotis subflavus* | 69 |
| | tricolored bat *Spilogale putorius interrupta* | 79 |
| Ellington Field Joint Reserve Base | alligator snapping turtle *Macrochelys temminckii* | 168 |
| | Correll's false dragonhead *Physostegia correllii* | 161 |
| | frosted elfin butterfly *Callophrys irus* | 57 |
| | golden-winged warbler *Vermivora chrysoptera* | 24 |
| | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Spilogale putorius interrupta* | 69 |
| | saltmarsh topminnow *Fundulus jenkinsi* | 43 |
| | tricolored bat *Perimyotis subflavus* | 79 |
| | western chicken turtle *Deirochelys reticularia miaria* | 180 |
| Fort Bliss | Chihuahua catfish *Ictalurus sp.* | 30 |
| | monarch butterfly *Danaus plexippus* | 63 |
| Fort Hood | false and Balcones spikes *Fusconaia mitchelli and iheringi* | 84 |
| | mimic cavesnail *Phreatodrobia imitata* | 113 |
| | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Perimyotis subflavus* | 69 |

## INSTALLATION REFERENCE TABLE

| Installation | Species | Page |
|---|---|---|
| Fort Hood cont. | Texas fawnsfoot<br>*Truncilla macrodon* | 128 |
| | tricolored bat<br>*Spilogale putorius interrupta* | 79 |
| | western chicken turtle<br>*Deirochelys reticularia miaria* | 180 |
| Goodfellow Air Force Base | monarch butterfly<br>*Danaus plexippus* | 63 |
| | plateau spot-tailed earless lizard<br>*Holbrookia lacerata* | 172 |
| | Texas fatmucket<br>*Lampsilis bracteata* | 122 |
| | Texas fawnsfoot<br>*Truncilla macrodon* | 128 |
| | Texas pimpleback<br>*Cyclonaias petrina* | 140 |
| | tricolored bat<br>*Spilogale putorius interrupta* | 79 |
| Joint Base San Antonio<br><br>Camp Bullis<br>Canyon Lake Recreation Annex<br>Fort Sam Houston<br>Kelly Field<br>Lackland Air Force Base<br>Randolph Air Force Base<br>Seguin Auxiliary Field | big red sage<br>*Salvia pentstemonoides* | 147 |
| | bracted twistflower<br>*Streptanthus bracteatus* | 153 |
| | Cascade Caverns salamander/<br>Comal blind salamander<br>*Eurycea latitans* | 16 |
| | Correll's false dragonhead<br>*Physostegia correllii* | 161 |
| | Edwards Aquifer diving beetle<br>*Haideoporus texanus* | 54 |
| | false and Balcones spikes<br>*Fusconaia mitchelli and iheringi* | 84 |
| | Guadalupe fatmucket<br>*Lampsilis bergmanni* | 90 |
| | Guadalupe orb<br>*Cyclonaias necki* | 96 |
| | mimic cavesnail<br>*Phreatodrobia imitata* | 113 |



## INSTALLATION REFERENCE TABLE

| Installation | Species | Page |
|---|---|---|
| Joint Base San Antonio cont. | monarch butterfly<br>*Danaus plexippus* | 63 |
| | plains spotted skunk<br>*Perimyotis subflavus* | 69 |
| | plateau spot-tailed earless lizard<br>*Holbrookia lacerata* | 172 |
| | Tamaulipan spot-tailed earless lizard<br>*Holbrookia subcaudalis* | 172 |
| | Texas salamander<br>*Eurycea neotenes* | 20 |
| | toothless blindcat<br>*Trogloglanis pattersoni* | 48 |
| | tricolored bat<br>*Spilogale putorius interrupta* | 79 |
| | western chicken turtle<br>*Deirochelys reticularia miaria* | 180 |
| | widemouth blindcat<br>*Satan eurystomus* | 48 |
| Laughlin Air Force Base<br><br>Laughlin AFB ALF | Chihuahua catfish<br>*Ictalurus sp.* | 30 |
| | Correll's false dragonhead<br>*Physostegia correllii* | 161 |
| | Mexican fawnsfoot<br>*Truncilla cognata* | 108 |
| | monarch butterfly<br>*Danaus plexippus* | 63 |
| | Pecos pupfish<br>*Cyprinodon pecosensis* | 33 |
| | plateau spot-tailed earless lizard<br>*Holbrookia lacerata* | 172 |
| | Rio Grande cooter<br>*Pseudemys gorzugi* | 177 |
| | Salina mucket<br>*Potamilus metnecktayi* | 116 |
| | Tamaulipan spot-tailed earless lizard<br>*Holbrookia subcaudalis* | 172 |

| Installation | Species | Page |
| --- | --- | --- |
| Laughlin Air Force Base cont. | tricolored bat *Spilogale putorius interrupta* | 79 |
| Naval Air Station Corpus Christi<br>NOLF Cabaniss<br>NOLF Goliad<br>NOLF Waldron | black-spotted newt *Notophthalmus meridionalis* | 13 |
| | golden-winged warbler *Vermivora chrysoptera* | 24 |
| | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Perimyotis subflavus* | 69 |
| | saltmarsh topminnow *Fundulus jenkinsi* | 43 |
| | Tamaulipan spot-tailed earless lizard *Holbrookia subcaudalis* | 172 |
| | tricolored bat *Spilogale putorius interrupta* | 79 |
| | western chicken turtle *Deirochelys reticularia miaria* | 180 |
| Naval Air Station Joint Reserve Base Fort Worth | alligator snapping turtle *Macrochelys temminckii* | 168 |
| | Louisiana pigtoe *Pleurobema riddellii* | 102 |
| | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Perimyotis subflavus* | 69 |
| | Texas fawnsfoot *Truncilla macrodon* | 128 |
| | Texas heelsplitter *Potamilus amphichaenus* | 133 |
| | tricolored bat *Spilogale putorius interrupta* | 79 |
| | western chicken turtle *Deirochelys reticularia miaria* | 180 |





| Installation | Species | Page |
| --- | --- | --- |
| Naval Air Station Kingsville<br>Dixie Target Range<br>NALF Orange Grove<br>Yankee Target Range | black-spotted newt *Notophthalmus meridionalis* | 13 |
| | golden-winged warbler *Vermivora chrysoptera* | 24 |
| | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Perimyotis subflavus* | 69 |
| | Tamaulipan spot-tailed earless lizard *Holbrookia subcaudalis* | 172 |
| | tricolored bat *Spilogale putorius interrupta* | 79 |
| | western chicken turtle *Deirochelys reticularia miaria* | 180 |
| National Guard Camp Bowie | false and Balcones spikes *Fusconaia mitchelli and iheringi* | 84 |
| | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Perimyotis subflavus* | 69 |
| | Texas fatmucket *Lampsilis bracteata* | 122 |
| | Texas fawnsfoot *Truncilla macrodon* | 128 |
| | Texas pimpleback *Cyclonaias petrina* | 140 |
| | tricolored bat *Spilogale putorius interrupta* | 79 |
| National Guard Camp Maxey | alligator snapping turtle *Macrochelys temminckii* | 168 |
| | frosted elfin butterfly *Callophrys irus* | 57 |
| | golden-winged warbler *Vermivora chrysoptera* | 24 |
| | monarch butterfly *Danaus plexippus* | 63 |
| | plains spotted skunk *Perimyotis subflavus* | 69 |

| Installation | Species | Page |
|---|---|---|
| National Guard Camp Maxey cont. | tricolored bat<br>*Spilogale putorius interrupta* | 79 |
| | western chicken turtle<br>*Deirochelys reticularia miaria* | 180 |
| National Guard Camp Swift | golden-winged warbler<br>*Vermivora chrysoptera* | 24 |
| | monarch butterfly<br>*Danaus plexippus* | 63 |
| | plains spotted skunk<br>*Perimyotis subflavus* | 69 |
| | Texas fawnsfoot<br>*Truncilla macrodon* | 128 |
| | Texas pimpleback<br>*Cyclonaias petrina* | 140 |
| | tricolored bat<br>*Spilogale putorius interrupta* | 79 |
| | western chicken turtle<br>*Deirochelys reticularia miaria* | 180 |
| National Guard Fort Wolters | monarch butterfly<br>*Danaus plexippus* | 63 |
| | plains spotted skunk<br>*Perimyotis subflavus* | 69 |
| | Texas fawnsfoot<br>*Truncilla macrodon* | 128 |
| | tricolored bat<br>*Spilogale putorius interrupta* | 79 |
| Red River Army Depot | alligator snapping turtle<br>*Macrochelys temminckii* | 168 |
| | frosted elfin butterfly<br>*Callophrys irus* | 57 |
| | golden-winged warbler<br>*Vermivora chrysoptera* | 24 |
| | Louisiana pigtoe<br>*Pleurobema riddellii* | 102 |
| | monarch butterfly<br>*Danaus plexippus* | 63 |





| Installation | Species | Page |
|---|---|---|
| Red River Army Depot cont. | plains spotted skunk<br>*Perimyotis subflavus* | 69 |
| | tricolored bat<br>*Spilogale putorius interrupta* | 79 |
| | western chicken turtle<br>*Deirochelys reticularia miaria* | 180 |
| Sheppard Air Force Base | monarch butterfly<br>*Danaus plexippus* | 63 |
| | plains spotted skunk<br>*Perimyotis subflavus* | 69 |
| | prairie chub<br>*Macrhybopsis australis* | 38 |
| | Texas kangaroo rat<br>*Dipodomys elator* | 74 |
| | tricolored bat<br>*Spilogale putorius interrupta* | 79 |

# Amphibians

**black-spotted newt**
**Cascade Caverns salamander**
**Comal blind salamander**
**Texas salamander**

## black-spotted newt

*Notophthalmus meridionalis*

### ESA Status

Under review, not on current 5-year workplan. In 2009, USFWS found that listing the species may be warranted.

### Identification

Adults approximately 54–110 mm (3.1–4.3 in.) in length. Body with large scattered black spots on back and belly, irregular yellowish stripes along back, and an orange or yellow-orange belly. Tail is vertically compressed with a keel or fin. The eft (terrestrial juvenile phase) is orange-red with stripes similar to the adults.

### Habitat

Found in typically xeric areas but is closely associated with shallow water in seasonally ephemeral and permanent streams, lagoons, ditches, and swampy areas containing large amounts of vegetation.

### Distribution

Coastal plains bordering the Gulf of Mexico from central Veracruz, Mexico north to southern Texas, USA.

### Management

Unknown

*Notophthalmus meridionalis (Toby J. Hibbitts)*

### Surveys

Bare (2018) compared different terrestrial survey techniques and detected 57 black-spotted newts during debris searches, 12 using cover boards, 8 using borescopes, 2 during visual roving surveys, and none using pitfall traps. Bare (2018) also found that environmental DNA (eDNA) surveys were effective at detecting black-spotted newts in aquatic environments.

### Threats cited by USFWS (2009)

- Herbicide and pesticide use

### Potential mitigation/translocation/propagation actions

Unknown

## black-spotted newt

*Notophthalmus meridionalis*

### References


Bare, E. A. 2018. Regional distribution, non-invasive detection, and genetic diversity of the black-spotted newt (*Notophthalmus meridionalis*). Thesis, University of Texas Rio Grande Valley, TX. https://doi.org/10.13140/RG.2.2.11711.05280

Dixon, J. R. 2013. Amphibians and Reptiles of Texas, 3rd edition, revised and updated. Texas A&M University Press, College Station, TX. https://www.tamupress.com/book/9781603447348/amphibians-and-reptiles-of-texas/

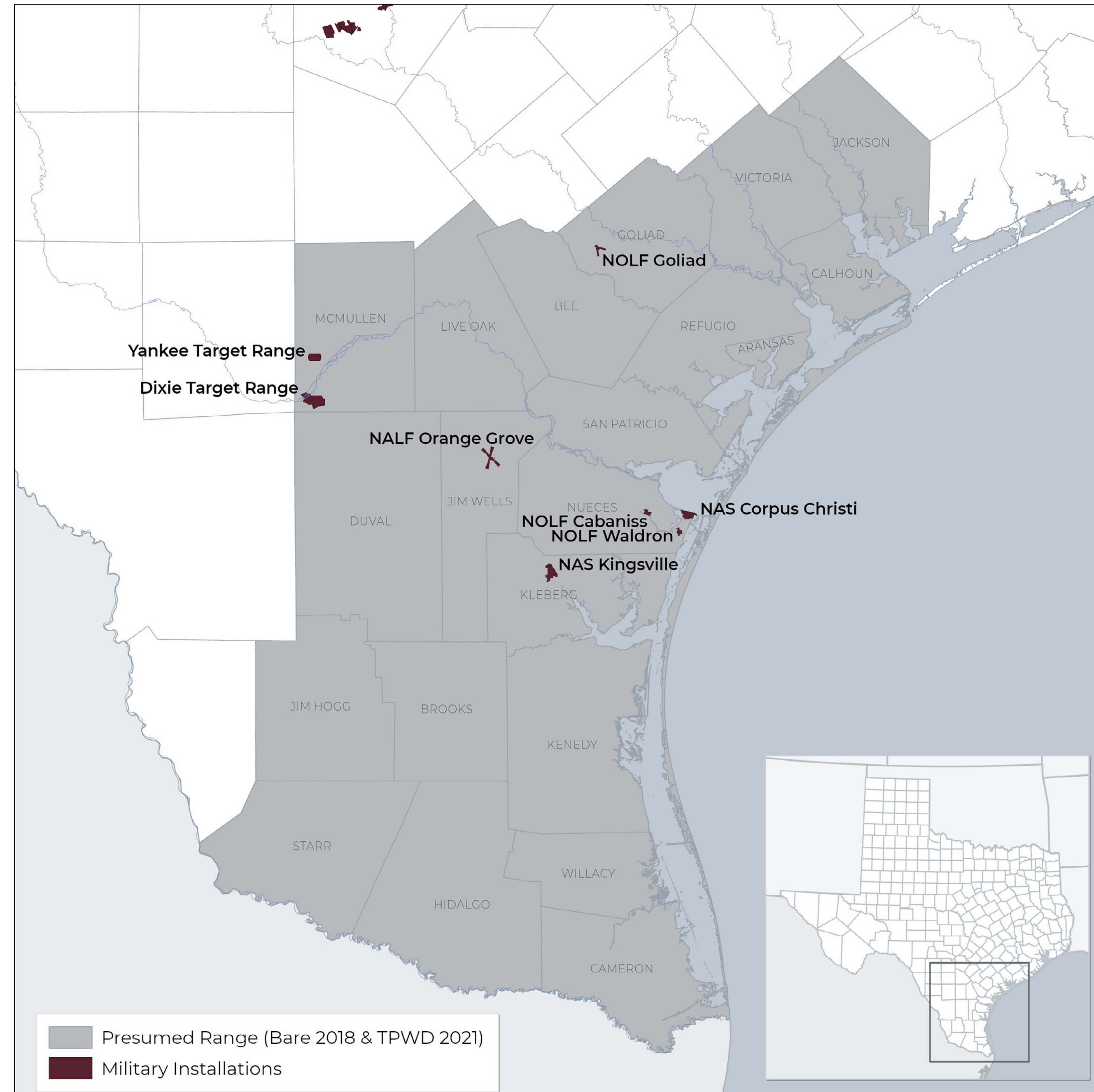
Tipton, B. L., T. L. Hibbitts, T. D. Hibbitts, T. J. Hibbitts, and T. J. LaDuc. 2012. Texas Amphibians: A Field Guide. University of Texas Press, Austin, TX. https://utpress.utexas.edu/books/tiptep

U.S. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and plants; partial 90-day finding on a petition to list 475 species in the southwestern United States as threatened or endangered with critical habitat. Federal Register 74:66865–66905. https://www.federalregister.gov/documents/2009/12/16/E9-29699/endangered-and-threatened-wildlife-and-plants-partial-90-day-finding-on-a-petition-to-list-475



## black-spotted newt

*Notophthalmus meridionalis*

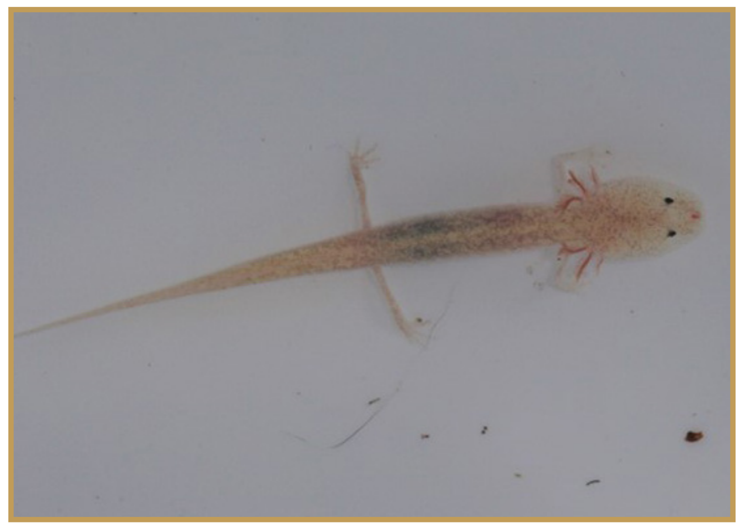
## Cascade Caverns salamander
## Comal blind salamander
*Eurycea latitans*

### ESA Status
Under review, on current 5-year workplan for FY22. In 2019, *Eurycea tridentifera* (Comal blind salamander) was placed in the synonymy of *E. latitans* (Devitt et al. 2019). In 2009 and 2015, USFWS found that listing *E. tridentifera* and *E. latitans*, respectively, may be warranted.

### Identification
Cascade Caverns salamander: Adult size ranges from 50–100 mm (2–4 in.) in length. Surface (stream) populations have yellow-brown backs with a translucent ventral side. They have normal sized eyes, with a dark bar between the eye and nostril, and 10–12 pairs of light dorsolateral spots along the body. Cave populations have reduced eyes and dorsal coloration, with a flattened snout and sloping forehead. They all have 4 toes on the front limbs, 5 on the hind limbs, and 14–15 costal grooves.

Comal blind salamander: Adults up to 85 mm (3.4 in.) long. Slender body and long head, sloping forehead and flattened snout. Reduced eyes, bright red external gills, long thin legs, and a finned tail. Reduced pigmentation, 4–15 pairs of dorsolateral light spots along body, with 11–12 costal grooves. They have 4 toes on the front limbs and 5 on the hind limbs.

*Cascade Caverns salamander (Toby J. Hibbitts)*



*Comal blind salamander (Toby J. Hibbitts)*

### Habitat
From TPWD Rare, Threatened, and Endangered Species of Texas database: Aquatic; springs, streams and caves with rocky or cobble beds.

### Distribution
Endemic to central Texas. Confirmed from Honey Creek Cave, Badweather Pit, and Pfeiffer's Water Cave, although there is evidence of admixture between *E. latitans* and *E. neotenes* (Texas salamander) at Pfeiffer's Water Cave (Devitt et al. 2019). The type locality is from Cascade Caverns, which was not sampled by Devitt et al. (2019).

## Cascade Caverns salamander
## Comal blind salamander
*Eurycea latitans*

### Management
See Tracy (2019).

### Surveys
See Tracy (2019).

### Threats cited by USFWS (2009, 2015)
- Groundwater withdrawal
- Groundwater contamination
- Decreasing water availability
- Decreased water quality
- Chemical spills
- Storm water runoff

### Potential mitigation/translocation/propagation actions
Although not much is known about this species, other *Eurycea* species have been successfully reared in captivity (Gratwicke and Murphy 2017).

### References
Chippindale, P. T., A. H. Price, J. J. Wiens, and D. M. Hillis. 2000. Phylogenetic relationships and systematic revision of central Texas hemidactyliine plethodontid salamanders. Herpetological Monographs 14:1–80. http://www.zo.utexas.edu/faculty/antisense/papers/HerpMono2000.pdf

Devitt, T. J., A. M. Wright, D. C. Cannatella, and D. M. Hillis. 2019. Species delimitation in endangered groundwater salamanders: implications for aquifer management and biodiversity conservation. PNAS 116:2624–2633. https://doi.org/10.1073/pnas.1815014116

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Gratwicke, B., and J. B. Murphy. 2017. History of captive management and conservation amphibian programs mostly in zoos and aquariums. Part II—Salamanders and Caecilians. Herpetological Review 48:474–486. https://repository.si.edu/bitstream/handle/10088/35009/Salamanders%20and%20caecilians%20FINAL%20Zoo%20View%20June%202017%20%281%29.pdf?sequence=1&isAllowed=y

## Cascade Caverns Salamander
## Comal blind salamander

*Eurycea latitans*

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Hillis, D. M., D. C. Cannatella, T. J. Devitt, and A. M. Wright. 2015. Genomic assessment of taxonomic status of central Texas *Eurycea* salamanders. Report submitted to U.S. Fish and Wildlife Service. https://tpwd.texas.gov/business/grants/wildlife/section-6/docs/amphibians_reptiles/tx-e-158-r_final-rpt-revised.pdf

Tipton, B. L., T. L. Hibbitts, T. D. Hibbitts, T. J. Hibbitts, and T. J. LaDuc. 2012. Texas Amphibians: A Field Guide. University of Texas Press, Austin, TX. https://utpress.utexas.edu/books/tiptep

Tracy, C. R. 2019. Biodiversity conservation of Morlocks in west-central Texas. PNAS 116:2410–2412. https://doi.org/10.1073/pnas.1821145116

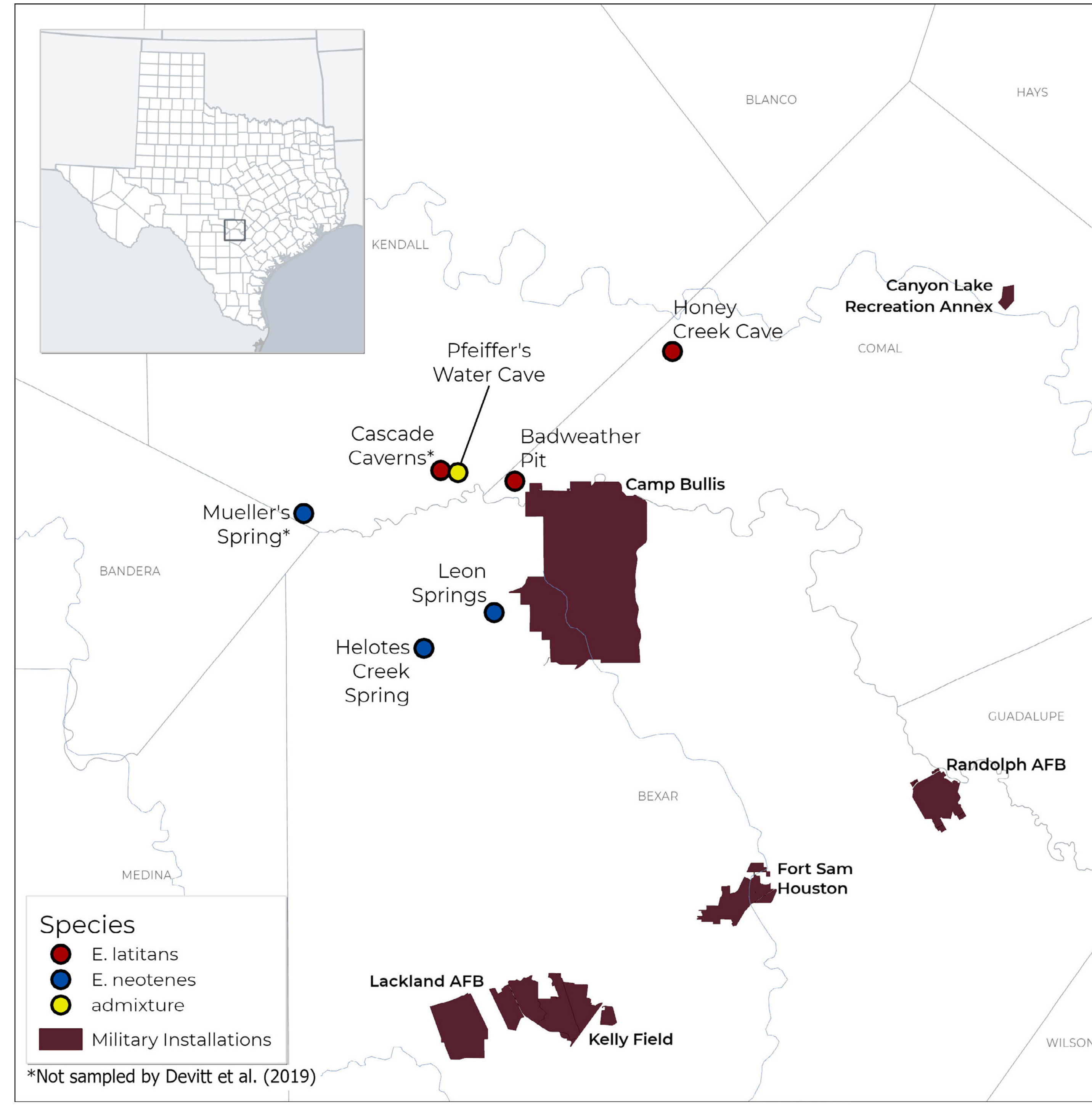
U.S. Fish and Wildlife Service. 2009. Endangered and threatened wildlife and plants; partial 90-day finding on a petition to list 475 species in the southwestern United States as threatened or endangered with critical habitat. Federal Register 74:66865–66905. https://www.federalregister.gov/documents/2009/12/16/E9-29699/endangered-and-threatened-wildlife-and-plants-partial-90-day-finding-on-a-petition-to-list-475

U.S. Fish and Wildlife Service. 2015. Endangered and threatened wildlife and plants; 90-day findings on 31 petitions. Federal Register 80:37568–37579. https://www.federalregister.gov/documents/2015/07/01/2015-16001/endangered-and-threatened-wildlife-and-plants-90-day-findings-on-31-petitions



## Cascade Caverns salamander
## Comal blind salamander

*Eurycea latitans*

## Texas salamander

*Eurycea neotenes*

### ESA Status

Under review, on current 5-year workplan for FY21. In 2009, UFSWS found that listing the species may be warranted.

### Identification

Adults are 50–100 mm (2–4 in.) in length. The slender body is light brown to yellow, with darker brown mottling and 2 rows of lighter flecks on each side of the body, with a translucent pale cream-colored ventral side. Head flattened, with dark bars from the nostril to eyes. Tail with narrow dorsal and ventral fins. They have 4 toes on the fore limbs, 5 toes on the hind limbs, and 15–17 costal grooves.

### Habitat

From TPWD's Rare, Threatened, and Endangered Species of Texas database (2021): Aquatic; springs, streams and caves with rocky or cobble beds.

### Distribution

Endemic to central Texas. Known from Helotes Creek Spring, Leon Springs, and Mueller's Spring. Additionally, there is evidence of admixture between *Eurycea netotenes* and *E. latitans* (Cascade Caverns salamander) at Pfeiffer's Water Cave (Devitt et al. 2019).

### Management

See Tracy (2019).

### Surveys

See Tracy (2019).

*Eurycea neotenes (Toby J. Hibbitts)*

### Threats cited by USFWS (2009)

- Drought

### Potential mitigation/translocation/ propagation actions

Although not much is known about this species, other *Eurycea* species have been successfully reared in captivity (Gratwicke and Murphy 2017).

### References


Chippindale, P. T., A. H. Price, J. J. Wiens, and D. M. Hillis. 2000. Phylogenetic relationships and systematic revision of central Texas hemidactyliine plethodontid salamanders. Herpetological Monographs 14:1–80. http://www.zo.utexas.edu/faculty/antisense/papers/HerpMono2000.pdf

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## Texas salamander

*Eurycea neotenes*


### References cont.


Gratwicke, B., and J. B. Murphy. 2017. History of captive management and conservation amphibian programs mostly in zoos and aquariums. Part II—Salamanders and Caecilians. Herpetological Review 48:474–486. https://repository.si.edu/bitstream/handle/10088/35009/Salamanders%20and%20caecilians%20FINAL%20Zoo%20View%20June%202017%20%281%29.pdf?sequence=1&isAllowed=y

Hillis, D. M., D. C. Cannatella, T. J. Devitt, and A. M. Wright. 2015. Genomic assessment of taxonomic status of central Texas Eurycea salamanders. Report submitted to U.S. Fish and Wildlife Service. https://tpwd.texas.gov/business/grants/wildlife/section-6/docs/amphibians_reptiles/tx-e-158-r_final-rpt-revised.pdf

Tipton, B. L., T. L. Hibbitts, T. D. Hibbitts, T. J. Hibbitts, and T. J. LaDuc. 2012. Texas Amphibians: A Field Guide. University of Texas Press, Austin, TX. https://utpress.utexas.edu/books/tiptep

Tracy, C. R. 2019. Biodiversity conservation of Morlocks in west-central Texas. PNAS 116:2410–2412. https://doi.org/10.1073/pnas.1821145116

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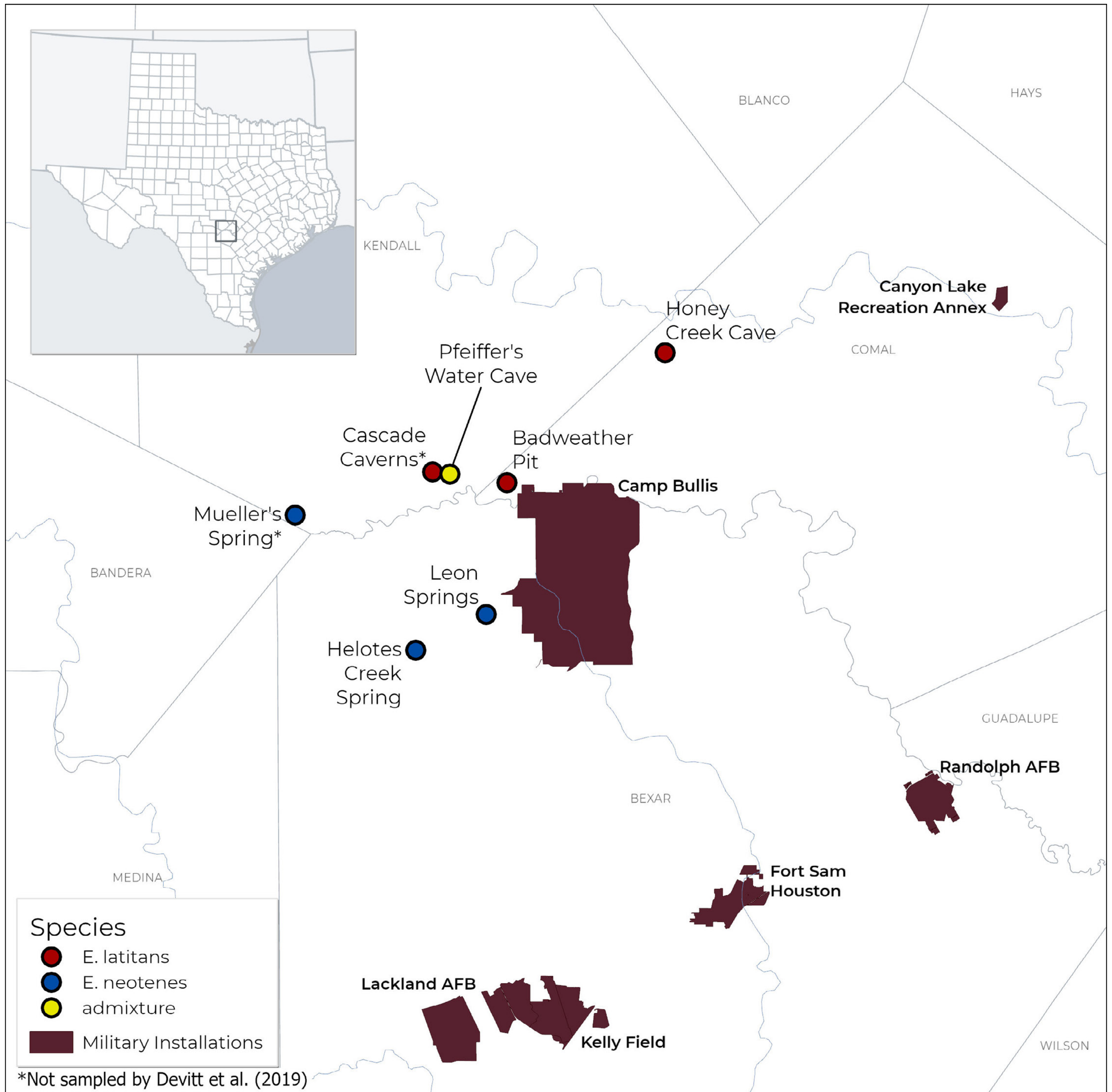
## Texas salamander
*Eurycea neotenes*




# Birds
### golden-winged warbler

## golden-winged warbler

*Vermivora chrysoptera*

### ESA Status

Under review, on current 5-year workplan for FY23. In 2011, USFWS found that listing the species may be warranted.

### Identification

Member of the wood warbler family (Parulidae); adult length 13 cm (5 in.), adult mean mass 9 g (0.3 oz.). Adult males silvery gray with yellow crown and wing patches and a black eye patch and throat with white bordering the eye patch. Adult females similar but the yellow and black patches are duller. Males sing two song types, both buzzy: type I is a long high note followed by several lower, shorter notes (*zee bee bee bee*) and type II is a rapid stutter followed by a lower buzzy note.

Golden-winged warblers hybridize with blue-winged warblers resulting in two hybrid forms known as Brewster's and Lawrence's. Brewster's are generally light gray and Lawrence's golden (see photos). Songs of hybrids match those of the parental species and are not intermediate in form.

### Habitat

Although extensive research has been conducted on breeding and wintering habitat, very little is known about golden-winged warbler habitat use during migration. According to the Golden-winged Warbler Status Review and Conservation Plan (Roth et al. 2019), a few

*Vermivora chrysoptera (Dennis Cooke; https://www.flickr.com/photos/69407414@N04/14259016757/)*

*Left: Brewster's warbler (Tom Murray; https://www.flickr.com/photos/tmurray74/34872470316/)*
*Right: Lawrence's warbler (Dominic Sherony; https://www.flickr.com/photos/9765210@N03/3513160337/)*

individuals have been recorded as transients in coastal, dry, and wet forests in the Caribbean region. Surveys as described below may help to remedy this lack of information.

### Distribution

Long-distance migrant: breeds in higher elevations of the Appalachian Mountains and northeastern and north-central US with a disjunct population from southeastern Ontario and adjacent Quebec northwest to Minnesota



## golden-winged warbler

*Vermivora chrysoptera*

### Distribution cont.

and Manitoba, and winters in southern Central America and northern South America. In Texas, uncommon to rare during spring migration and rare to very rare during fall migration in the eastern third of the state; the map below displays counties identified in Lockwood and Freeman (2014).

### Management

Very little is known about golden-winged warbler habitat use during migration, and without this information, it is difficult to determine effective management strategies for the migratory portion of the species' life cycle. However, there are several ongoing studies utilizing light-level geolocators that may reveal important migration stopover regions that could then be targeted for management.

### Surveys

Surveying for migrating warblers is often much more difficult than surveying for breeding warblers, as migrating warblers typically do not sing as often or as loudly as breeding warblers, if at all. However, point counts and mist netting/banding are viable options for determining presence/absence and relative abundance in an area during migration. Additionally, recording habitat characteristics at point count and mist net locations can help to reveal migratory habitat preferences. An ideal study would incorporate all three types of surveys (point counts, mist netting/banding, and habitat surveys), but may not be feasible due to lack of banding experience or resources. If a study is limited due to personnel but not banding experience/permitting, mist netting/banding along with habitat surveys is the best option. If mist netting/banding is not an option, point counts and habitat surveys will suffice, although this may result in an underestimation of abundance, as point counts are not as reliable as mist netting/banding at detecting migrating warblers.

The Midwest Migration Network has developed a standardized protocol for migration monitoring called the Landbird Migration Banding Initiative (LMBI). Although Texas is not included in the Midwest Region, the protocol is a great resource for migration monitoring and a link to the operations manual can be found below (Midwest Migration Network 2018). The surveys mentioned above and described in the LMBI operations manual are not restricted to a single species so are beneficial for more than just golden-winged warblers.

## golden-winged warbler

*Vermivora chrysoptera*

**Surveys cont.**

Furthermore, when conducting mist netting/banding, golden-winged warblers can be affixed with small, lightweight radio transmitters that are registered to the Motus Wildlife Tracking System. This allows for warblers to be tracked as they continue their migration and can provide information on how long they stay in an area. More information can be found at motus.org.

**Threats cited by USFWS (2011)**

- Habitat modification and loss of early successional habitat
- Inadequacy of existing regulatory mechanisms
- Interactions with blue-winged warblers

**Migratory threats cited by Roth et al. (2019)**

- Collisions with communication towers and buildings

**Potential mitigation/translocation/propagation actions**

Until we know more about golden-winged warbler habitat use during migration, potential mitigation actions for the migratory portion of the species' life cycle remain unknown.

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## golden-winged warbler

*Vermivora chrysoptera*

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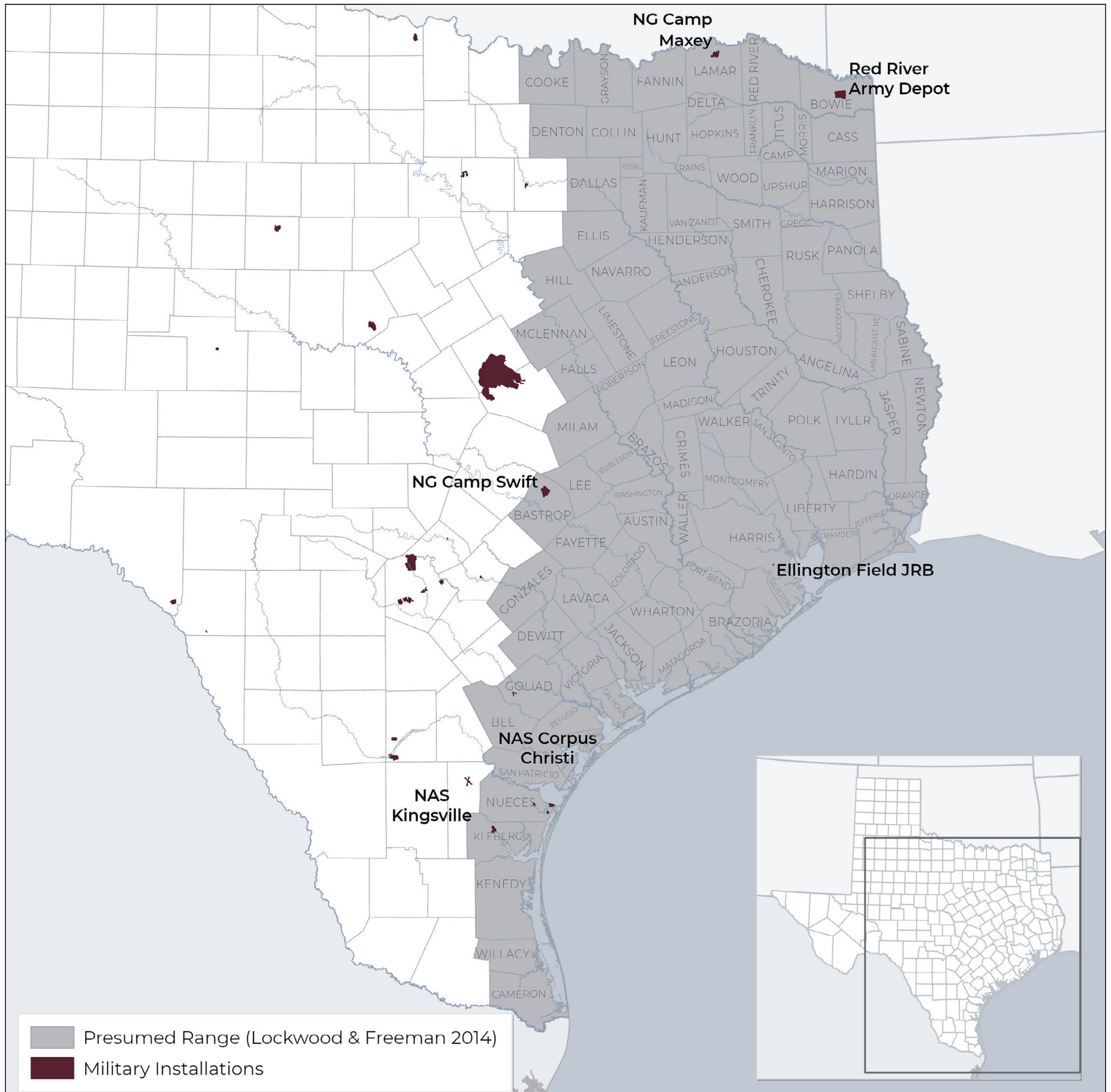
## golden-winged warbler

*Vermivora chrysoptera*




# Fish

**Chihuahua catfish**
**Pecos pupfish**
**prairie chub**
**saltmarsh topminnow**
**toothless blindcat**
**widemouth blindcat**

## Chihuahua catfish
*Ictalurus sp.*

*Ictalurus sp Chihuahua catfish (Fishes of Texas Project; http://www.fishesoftexas.org/taxa/ictalurus-sp-chihuahua-catfish)*

### ESA Status
Under review, on current 5-year workplan for FY23. In 2009, USFWS found that listing the species may be warranted.

### Identification
The Chihuahua catfish appears similar to *Ictalurus lupus* (headwater catfish) but can be differentiated by its heavy-set body, broader head and mouth, uniquely shaped mandible, pectoral girdle, and pectoral spine, reduced number of anal rays and vertebrae, larger vomer, deeper caudal peduncle, weakly forked caudal fin, and shorter dorsal and pectoral spines. It hybridizes with both *I. lupus* and *I. punctatus* (channel catfish), making identification difficult.

### Habitat
From TPWD's Rare, Threatened, and Endangered Species of Texas database (2021): Inhabits the middle to upper parts of moderate to large rivers and also occurs in small, headwater creeks and springs over gravel, rubble, rocks, boulders and mud substrates.

### Distribution
Rio Grande basin in Texas, New Mexico, and northern Mexico. Also found in the Gila River in New Mexico.

### Management
Unknown

### Surveys
Effective sampling techniques for this species have not been studied but Bodine et al. (2013) provide a review of sampling techniques for other catfish species.

### Threats cited by USFWS (2009)
- Pollution
- Dewatering
- Non-native species

### Potential mitigation/translocation/ propagation actions
There are currently no studies relating to the mitigation, translocation, or propagation of Chihuahua catfish. However, other species of catfish (including channel catfish) have been widely studied and propagated.

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## Chihuahua catfish
*Ictalurus sp.*

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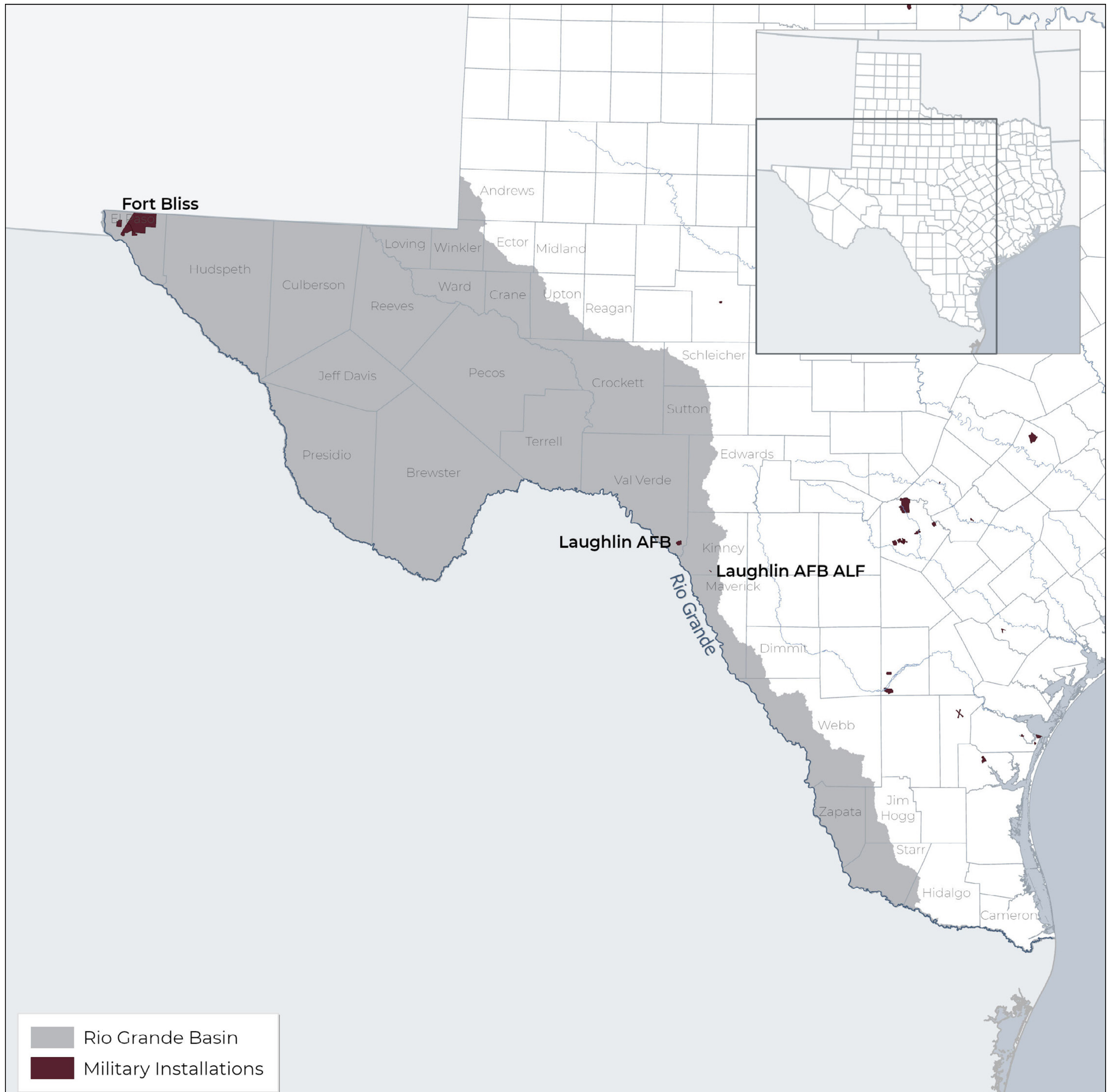
## Chihuahua catfish

*Ictalurus sp.*




## Pecos pupfish

*Cyprinodon pecosensis*

*Male Cyprinodon pecosensis (Chad Thomas; Fishes of Texas Project; http://www.fishesoftexas.org/taxa/cyprinodon-pecosensis)*

*Female Cyprinodon pecosensis (Chad Thomas; Fishes of Texas Project; http://www.fishesoftexas.org/taxa/cyprinodon-pecosensis)*

### ESA Status

Under review, not on current 5-year workplan. In 2009, USFWS found that listing the species may be warranted.

### Identification

From Fishes of Texas Project (2021): *Maximum size*: 60 mm (2.36 in.) TL (Page and Burr 1991).

*Coloration*: From Sublette et al. (1990): nonbreeding males, juvenile males, and females brownish to greenish dorsolaterally with 7–9 dark lateral bars which expand into blotches; scattered blotches on lower sides; abdomen whitish. Dark crescent at base of caudal fin on females (Echelle and Echelle 1978); dark ocellus near the posterior base of dorsal fin, although Garrett (1980) noted that males in many populations of this species begin losing the dorsal ocellus long before the onset of sexual maturity. Young adult males have maintained the female color pattern when in small tanks with large males (Garrett 1980). Breeding males grayish blue to iridescent blue dorsolaterally; abdomen, cheeks, and opercles whitish; dorsal and anal fins black; black crescent at base of caudal fin; caudal fin with black terminal band; pectoral fins pale yellow (Echelle and Echelle 1978). The bright blue male nuptial coloration signals the possession of a territory, the ability of the owner to defend it, and the quality of that individual as a potential mate (Kodric-Brown 1977, 1983; Kodric-Brown and Nicoletto 1993).

*Counts*: Usually 2–3 mandibular pores (Page and Burr 1991).

*Mouth position*: Upturned (Page and Burr 1991). Mouth superior, lower jaw projecting (Sublette et al. 1990).

*Body shape*: Caudal peduncle depth more than distance from snout to back of head; in adults, greatest body depth contained less than 2.5 times in standard length; distance from origin of dorsal fin to end of hypural plate less than the distance from origin of dorsal to anterior nostril (Hubbs et al. 2008).

*External morphology*: Abdomen naked anterior to pelvics (Hubbs et al. 2008).

*Internal morphology*: Numerous tricuspid teeth on each jaw (Sublette et al. 1990).

## Pecos pupfish
*Cyprinodon pecosensis*

### Habitat
From Fishes of Texas Project (2021):
*Macrohabitat*: Species occurs in saline springs, gypsum sinkholes and desert streams (Allen 1980).

*Mesohabitat*: Although collected in low salinity waters, this species most typical in highly saline habitats that support relatively few species (Echelle and Echelle 1978; Allen 1980). Species tolerant to extremes in environmental factors (i.e., temperature, salinity, and dissolved oxygen; Albeit 1982).

### Distribution
Pecos River in Texas and New Mexico.

### Management
Suggested conservation actions include habitat protection and restoration through protection of groundwater and surface water from depletion and contamination, control of saltcedar (*Tamarix* spp.), erosion control, protection of riparian communities, and river channel restoration, protection from genetic contamination through monitoring for hybrids and eliminating them if possible, constructing barriers to hybrid dispersal, and establishing hatchery stocks, and non-native fish control including sheepshead minnow (*Cyprinodon variegatus*), inland silverside (*Menidia beryllina*), and gulf killifish (*Fundulus grandis*).

### Surveys
The New Mexico Department of Game and Fish sampled all known populations of Pecos pupfish between 1987 and 1998 using a combination of seining, minnow trapping, and dip netting (Hoagstrom and Brooks 1999). Minnow trapping was the most commonly used method of fish capture followed by seining. Dip netting was not as effective but was useful for determining presence/absence if time was limited.

### Threats cited by USFWS (2009)
- Water quality and quantity issues
- Hybridization with the sheepshead minnow

### Potential mitigation/translocation/propagation actions
Unknown



## Pecos pupfish
*Cyprinodon pecosensis*

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## Pecos pupfish

*Cyprinodon pecosensis*


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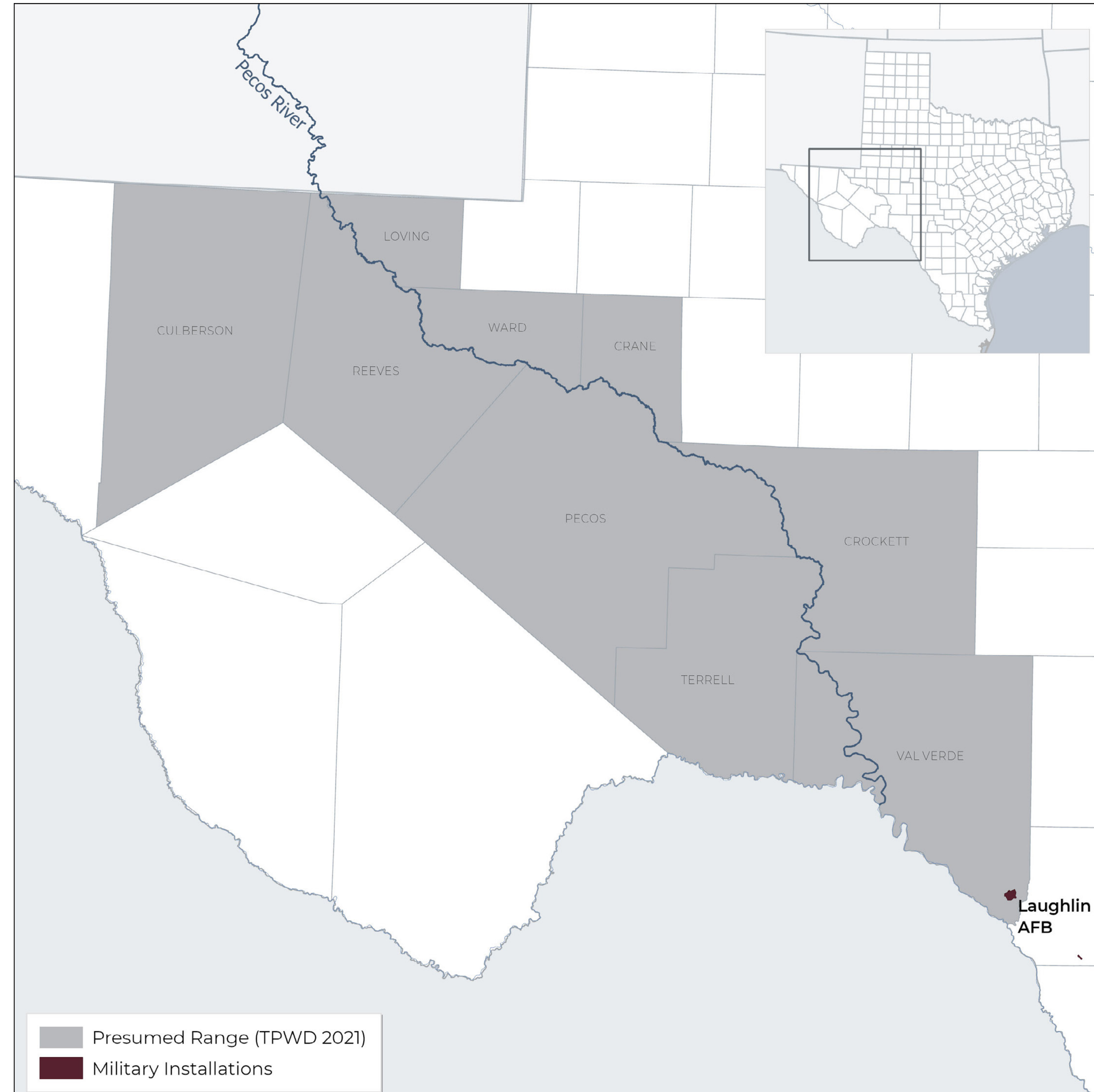
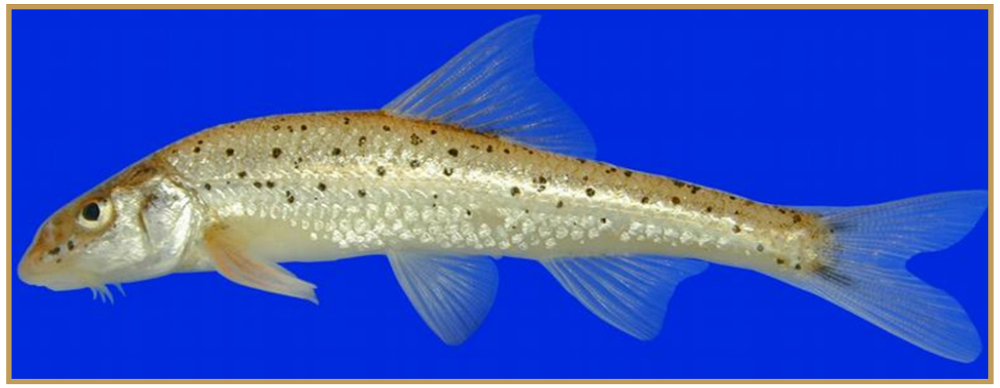
## Pecos pupfish

*Cyprinodon pecosensis*



## prairie chub
*Macrhybopsis australis*



*Macrhybopsis australis (Chad Thomas; Fishes of Texas Project; http://www.fishesoftexas.org/taxa/macrhybopsis-australis)*

### ESA Status
Under review, not on current 5-year workplan. In 2009, USFWS found that listing the species may be warranted.

### Identification
From Fishes of Texas Project (2021):
*Maximum size*: 70 mm (2.76 in.) TL (Eisenhour 2004).

*Coloration*: Pallid and translucent, in life, pale yellow or gray dorsally, silvery white ventrally, with broad silver mid-lateral stripe; small melanophores scattered over dorsolateral surface of body, not concentrated on margin or submargin of scales; poorly defined mid-lateral stripe present to nearly absent, composed of small, often X-shaped melanophores, centered one scale row above lateral line; dorsal fin with fairly dark pigment on basal third of first 3–5 rays; pigment on distal portion of rays lacking or reduced. Pectoral, pelvic, and anal fins generally lacking pigment; rarely some pigment on pectoral rays (Eisenhour 2004).

*Counts*: Pharyngeal teeth 0,4–4,0; 19 (16–20) principal caudal fin soft rays; 7 (6–8) anal fin soft rays; 7–8 (6–9) pelvic fin soft rays; 13–15 (12–17) pectoral fin soft rays; 36–42 (34–44) lateral-line scales; 2–16 (0–19) predorsal scales; 5–6 (4–7) scales above lateral line; 4–5 (4–6) scales below lateral line; 12–16 (12–17) caudal peduncle scales; 12–16 (10–16) infraorbital pores; 10–12 (9–14) preoperculomandibular pores; 35–36 (34–36) total vertebrae; 16–18 (16–19 precaudal vertebrae; 17–19 caudal vertebrae (Eisenhour 2004).

*Mouth position*: Inferior and horizontal; width equal to head width when viewed ventrally; lips very fleshy and thickened posteriorly (Eisenhour 2004).

*Body shape*: Fusiform with moderately slender caudal peduncle; head conical and flattened ventrally with long and relatively pointed snout (Eisenhour 2004).

*Morphology*: Nape fully scaled or with scattered embedded scales, rarely naked; belly posterior to pelvic fin bases naked to fully scaled; belly just anterior to pelvic fin bases naked or with few scales not forming a bridge across belly. Anal and dorsal fins slightly falcate; pelvic fins pointed; pectoral fins long and falcate, reaching past bases of pelvic fins in adult males and just reaching bases of pelvic fins in adult females; eyes tiny and round (or nearly so); 2 prominent pairs of maxillary barbels present, the more posterior pair greater than orbit length and the anterior pair >50% of orbit length; cutaneous taste buds expanded into large papillae on gular area; in both sexes, genital papillae poorly developed as small conical or cylindrical extensions; gill rakers on first arch absent or present as 1–3 dorsal rudiments (Eisenhour 2004). In large nuptial males, pectoral rays 2–10 are greatly thickened with rows of small, conical, antrorse, recurved biserial tubercles; basal



prairie chub
*Macrhybopsis australis*

### Identification cont.
part of rays and primary branches each with 1–2 rows of tubercles; 2 tubercles per fin ray segment on posterior primary branch, 1–2 tubercles per segment on the anterior primary branch; tubercles arranged uniserially on secondary branches (Eisenhour 2004).

### Habitat
From Fishes of Texas Project (2021):
*Macrohabitat*: Medium to large streams (Eisenhour 2004).

*Mesohabitat*: Found in flowing water over coarse sand and fine gravel substrates in streams; occupies intermittent streams that may dry to isolated, salt-encrusted pools (Winston et al. 1991; Eisenhour 2004). Distribution is correlated with high levels of dissolved salts (Taylor et al. 1993; Eisenhour 2004; Higgins and Wilde 2005); reported from waters with salinities up to 19.6 ppt (Echelle et al. 1972; Eisenhour 2004).

### Distribution
Upper Red River basin in Texas and Oklahoma.

### Management
Current distribution and abundance data are limited and population trends are unknown, making it difficult to identify management issues and establish effective corrective strategies. Of high priority is to assess the current distribution and abundance of the species throughout its range. However, see Mollenhauer et al. (2021).

### Surveys
All studies reviewed used seines to capture prairie chub. Ruppel et al. (2020) explained that seining is the optimal sampling technique for this species because seines are ideal for sampling large areas of wadeable habitats, environmental variables can be accurately quantified, fish are obtained with limited trauma, and seines are effective in water bodies with fine substrates, shallow water depths, few snags, and slow current velocities. The upper Red River also has elevated specific conductance, eliminating electroshocking as an option.

### Threats cited by USFWS (2011)
- Altered stream flows
- Degraded water quality
- Inadequacy of existing regulatory mechanisms

## prairie chub
*Macrhybopsis australis*

### Potential mitigation/translocation/propagation actions
Unknown

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## prairie chub
*Macrhybopsis australis*

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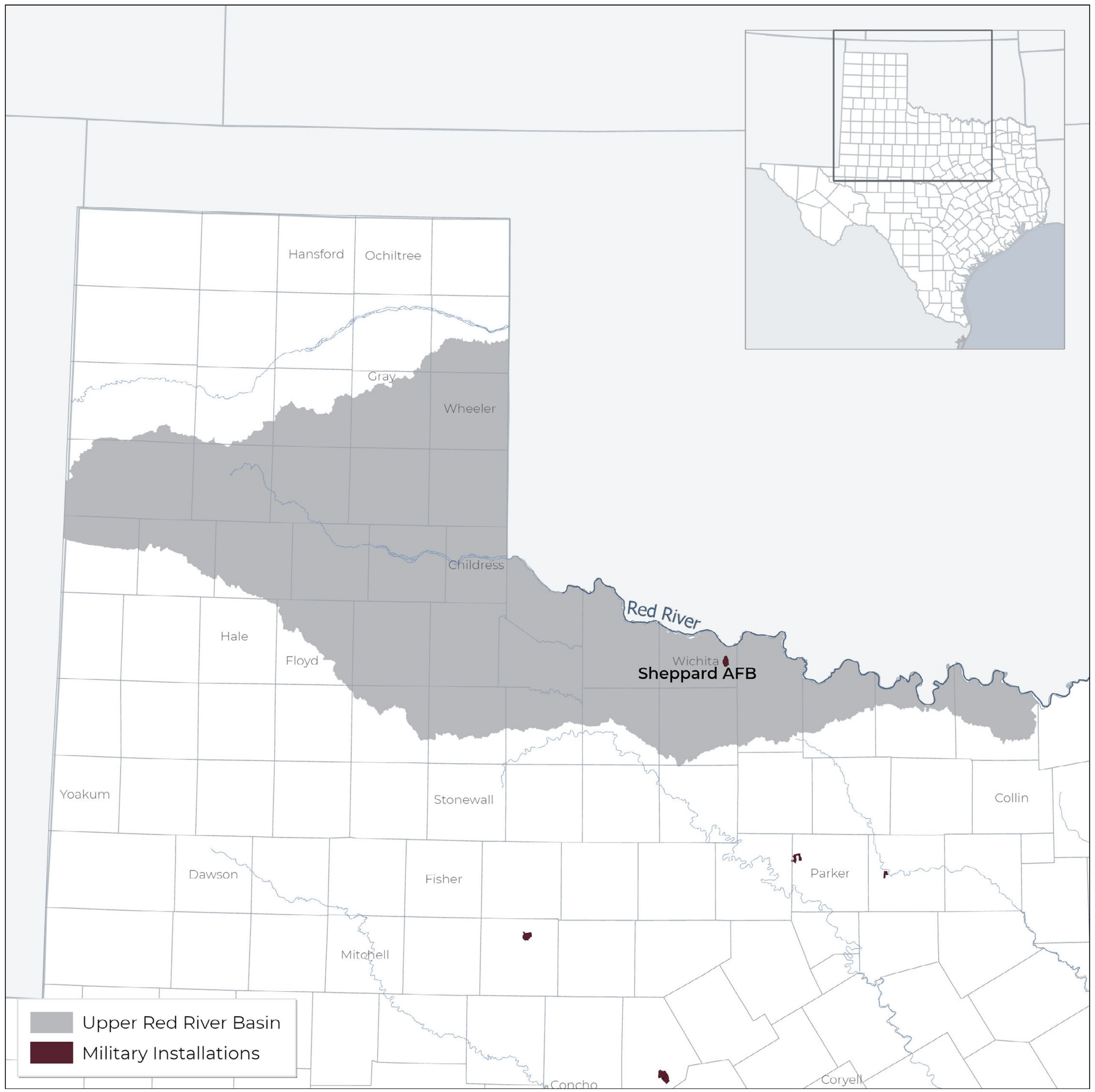
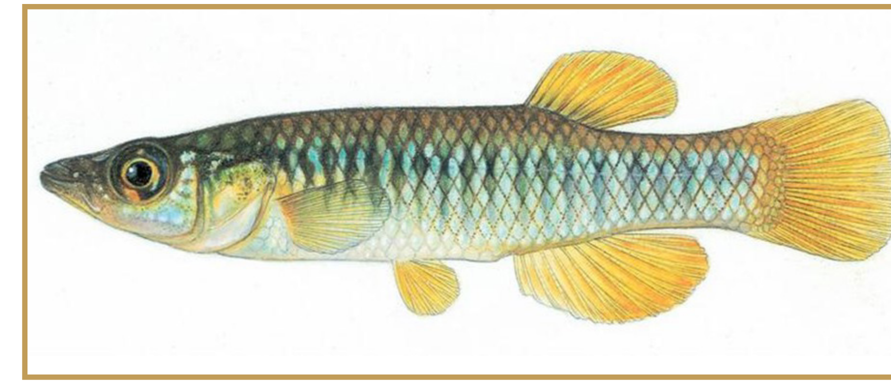
## prairie chub
*Macrhybopsis australis*




## saltmarsh topminnow
*Fundulus jenkinsi*



*Fundulus jenkinsi (Joseph R. Tomelleri; Fishes of Texas Project; http://www.fishesoftexas.org/taxa/fundulus-jenkinsi)*

### ESA Status
Under review, on current 5-year workplan for FY22. In 2011, USFWS found that listing the species may be warranted.

### Identification
Saltmarsh topminnows are typically smaller than 45 mm (1.77 in.) in length and have cross-hatching on their backs and sides that may be gray-green. Most individuals have several round, black spots arranged in rows along the midside of the body from above the pectoral fin to the base of the caudal fin. Males have longer median fins and develop a lemon-yellow color on anal fins, while females have a sheath on the anterior base of the anal fin that is used to position eggs during spawning.

### Habitat
From TPWD's Rare, Threatened, and Endangered Species of Texas database (2021): Occupies estuaries and the edges of saltmarsh habitats along the Gulf Coast in salinities of 4–20 ppt in *Spartina*-dominated tidal creeks and wetlands (Griffith 1974; Peterson and Ross 1991; Peterson and Turner 1994; Lopez et al. 2010). Requires access to small interconnected tidal creeks for feeding and reproduction. Spawning occurs from March to August during high tide events (Robertson 2016). Non-migratory.

### Distribution
Saltmarsh habitat along the northern Gulf of Mexico from Florida to Texas. In Texas, reported from as far west as Nueces County (Nicolau 2001).

### Management
Suggested conservation actions include maintaining and restoring saltmarsh habitat, limiting the use of hardened structures and dredging, protecting water quality, preserving and restoring interconnected tidal creeks, and surveying for and monitoring populations of the species.

### Surveys
Studies reviewed used seines, Breder traps, flume nets, dip nets, minnow traps, drop samplers, frame nets, wire mesh traps, or a combination of methods to capture saltmarsh topminnows. Most individuals were captured along marsh edges or in tidal creeks. Fulling et al. (1999) found that Breder traps were more effective at sampling Fundulidae than seines.

### Threats cited by USFWS (2011)
- Losses of and threats to the species' saltmarsh habitat
- Inadequacy of mechanisms to protect the fish or its habitat
- The species' biological parameters including low rate of reproduction and limited individual ranges

## saltmarsh topminnow

*Fundulus jenkinsi*

### Threats cited by Florida Fish and Wildlife Conservation Commission (2013)

- Changes in water quality and quantity
- Channelization or ditching in the saltmarsh
- Dredging
- Habitat alteration
- Encroachment of urbanization
- Point source and non-point source pollution

### Potential mitigation/translocation/propagation actions

Unknown

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## saltmarsh topminnow

*Fundulus jenkinsi*

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## saltmarsh topminnow
*Fundulus jenkinsi*

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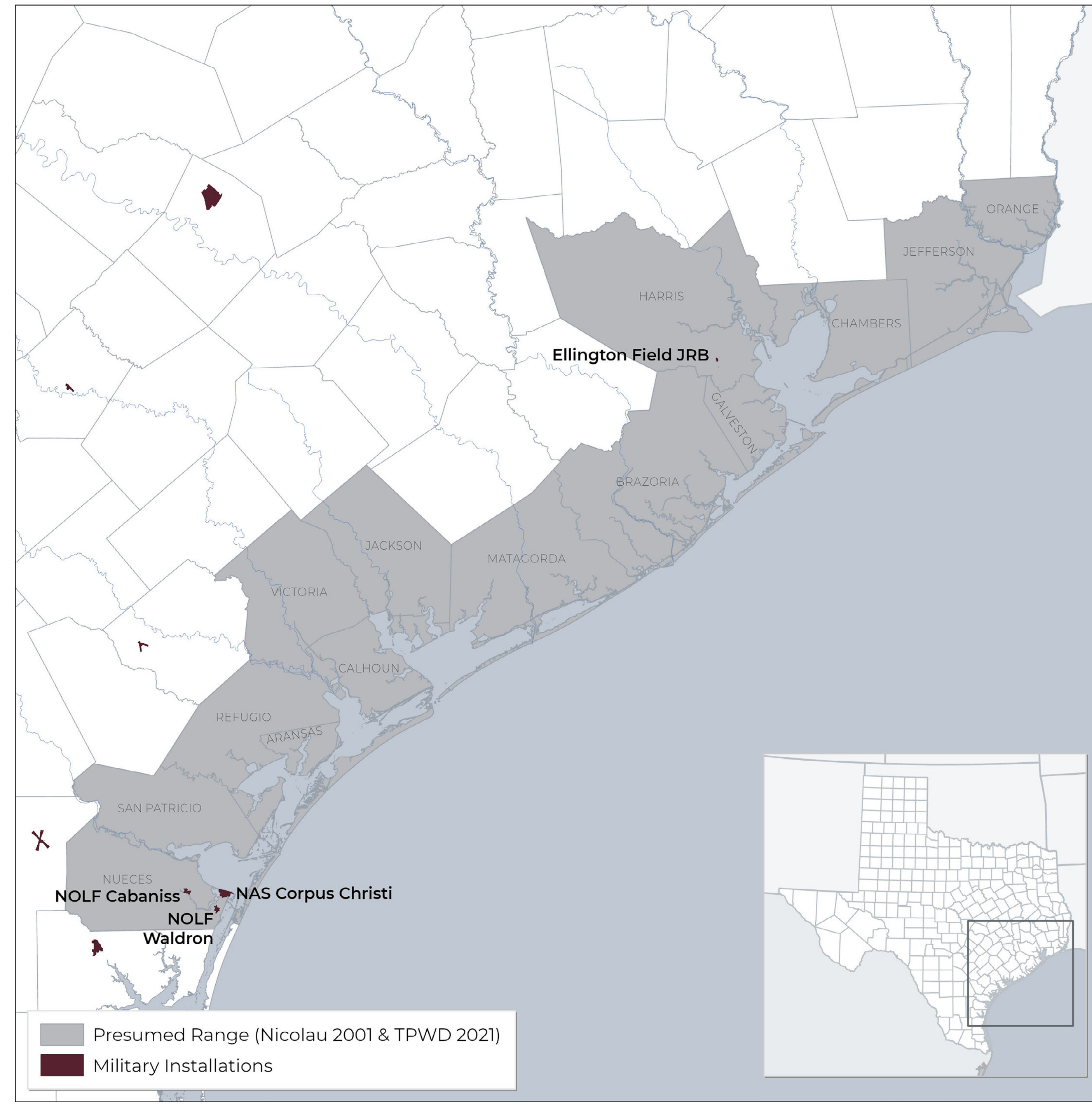
## saltmarsh topminnow
*Fundulus jenkinsi*

## widemouth blindcat

*Satan eurystomus*

## toothless blindcat

*Trogloglanis pattersoni*

### ESA Status

Under review, on current 5-year workplan for FY20 but a decision has not been published yet. In 2009, USFWS found that listing these species may be warranted.

### Identification

From Fishes of Texas Project (2021):

widemouth blindcat

*Maximum size*: 136.9 mm (5.39 in.) (Longley and Karnei 1979).

*Coloration*: White or pink (from blood pigments; Page and Burr 1991).

*Counts*: 19–20 anal rays (Page and Burr 1991).

*Body shape*: Small body size compared to other ictalurid species (Langecker and Longley 1993). Well developed teeth on jaws; lips at corner of mouth thick (Hubbs and Bailey 1947; Hubbs et al. 2008). Lower jaw normal in shape, slightly shorter than upper jaw; broad, flat head and snout (Page and Burr 1991). No air bladder (Hubbs and Bailey 1947).

*Mouth position*: Transverse (Hubbs and Bailey 1947).

*External morphology*: Lateral line canals and pores on head well developed (Hubbs and Bailey 1947); no eyes; separate gill membranes with strong fold between them; long, high adipose fin; relatively short anal fin, rounded in outline; rear edge of caudal fin straight or slightly notched (Page and Burr 1991).

*Satan eurystomus (Fishes of Texas Project; http://www.fishesoftexas.org/taxa/satan-eurystomus)*

*Trogloglanis pattersoni (Chad Thoms; Fishes of Texas Project; http://www.fishesoftexas.org/taxa/trogloglanis-pattersoni)*

toothless blindcat

*Maximum size*: 104 mm (4.09 in.) (Page and Burr 1991); standard length of the 47 known specimens of *Trogloglanis pattersoni* ranges from 16–89 mm (0.63–3.50 in.) (Langecker and Longley 1993).

*Coloration*: White or pink body, red mouth (from blood pigments; Page and Burr 1991).

*Counts*: 16–17 anal rays (Page and Burr 1991).

*Body shape*: Small compared to other ictalurid species (Langecker and Longley 1993); lips at the corner of mouth thin (Hubbs et al. 2008); short lower jaw curved upward and into mouth; snout overhangs mouth (Page and Burr 1991).

*Mouth position*: Ventrally placed, toothless sucker-mouth (Langecker and Longley 1993). Greatly inverted (Hubbs and Bailey 1947).



## widemouth blindcat

*Satan eurystomus*

## toothless blindcat

*Trogloglanis pattersoni*

### Identification cont.

*External morphology*: No eyes (Hubbs et al. 2008); poor development of lateral-line system; relatively short maxillary barbels (Lundberg 1982); short lower gill membranes with barely visible fold between them; long, high adipose fin joined to caudal fin; short anal fin, rounded in outline; rear edge of caudal fin straight or slightly notched; no air bladder (Page and Burr 1991).

### Habitat

From Fishes of Texas Project (2021):

*Macrohabitat*: Subterranean waters (Page and Burr 1991).

*Mesohabitat*: Found at depths of 305–582 m (1001–1909 ft.) (Cooper and Longley 1980; Hubbs et al. 2008); in water temperature 27°C (wells with 24°C water in north and northwestern Bexar County have not produced either species; Cooper and Longley 1980). These species, which lack air bladders, live under great hydrostatic pressure (Hubbs and Bailey 1947).

### Distribution

From Fishes of Texas Project (2021): Restricted to 5 artesian wells penetrating the San Antonio Pool of the Edwards Aquifer (Edwards Limestone, Lower Cretaceous) in Bexar County, Texas (Cooper and Longley 1980; Page and Burr 1991; Warren et al. 2000; Hubbs et al. 2008). Longley and Karnei (1979) provide detailed notes on distribution.

### Management

These species would benefit from consistent groundwater conservation, protection from contamination, and responsible extraction (e.g., industrial use for oil and gas, human consumption).

### Surveys

Most specimens of these species were pumped from artesian wells. Langecker and Longley (1993) state that the specimens used in their study were collected from artesian wells or pump stations having nets attached to the outlets, and that sampling was conducted every 2–3 days.

## widemouth blindcat
*Satan eurystomus*
## toothless blindcat
*Trogloglanis pattersoni*

### Threats cited by USFWS (2009)
- Water drawdown and pollution
- Competition from exotic species

### Potential mitigation/translocation/propagation actions
Although no studies have investigated potential mitigation, translocation, and propagation actions for these species, they are likely not viable management options because both species are so narrowly endemic and have only been found in inaccessible portions of the aquifer's deep artesian zones.

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## widemouth blindcat
*Satan eurystomus*
## toothless blindcat
*Trogloglanis pattersoni*


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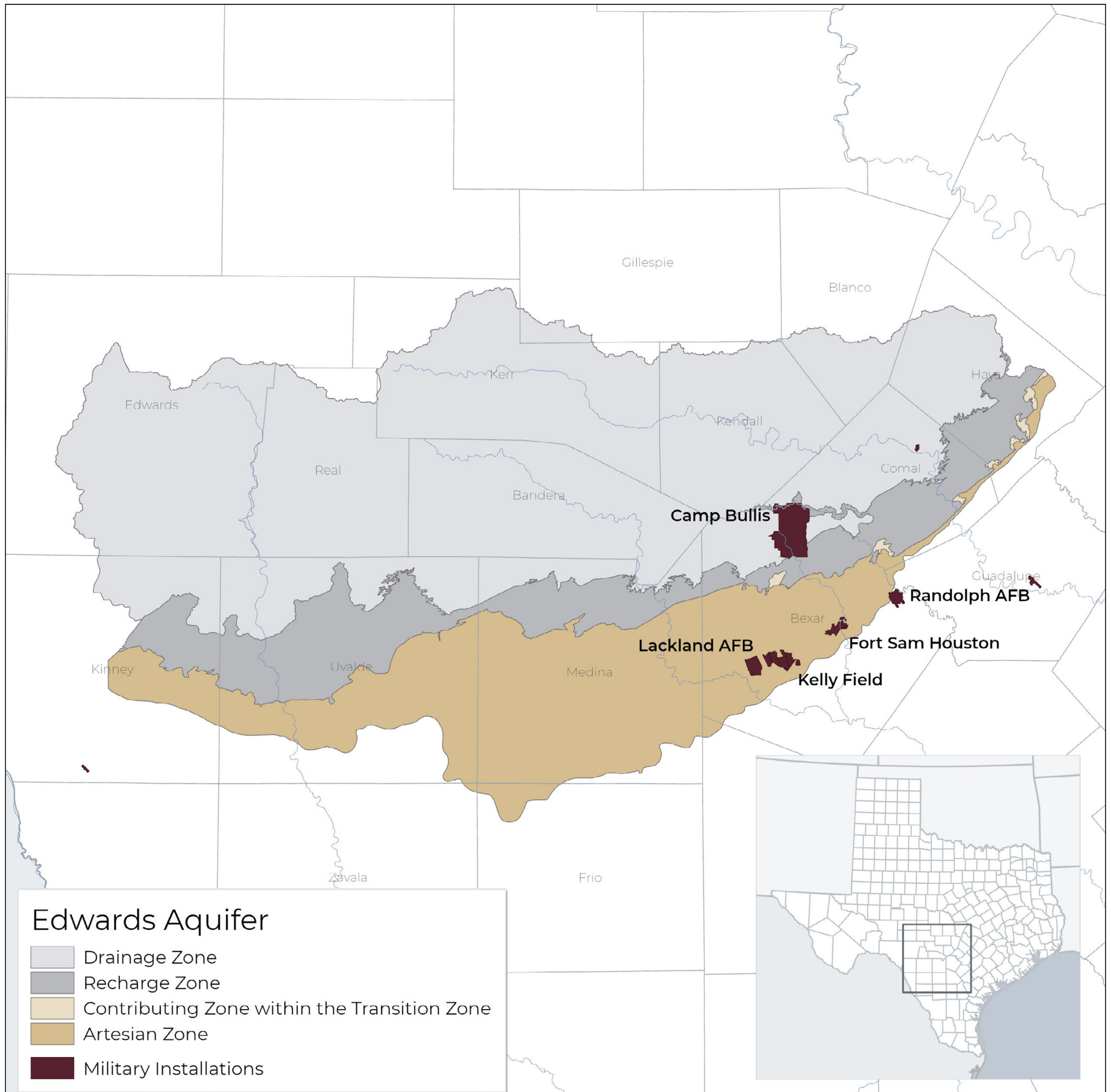
## widemouth blindcat

*Satan eurystomus*

## toothless blindcat

*Trogloglanis pattersoni*




# Insects

**Edwards Aquifer diving beetle**
**frosted elfin butterfly**
**monarch butterfly**

## Edwards Aquifer diving beetle
*Haideoporus texanus*

### ESA Status
Under review, on current 5-year workplan for FY22. In 2009, USFWS found that listing the species may be warranted.

### Identification
Small elongate ovate and somewhat flattened dytiscid beetle in the subfamily Hydroporinae. This species has reduced eyes and pigmentation, lacks hindwings, and is covered in sensory setae (Young and Longley 1976).

### Habitat
Subterranean waters in the artesian zone of the Edwards Aquifer.

### Distribution
This species has only been collected from the artesian well at Texas State University in Hays County, Texas and from spring openings in the Comal Springs system in Comal County, Texas; the complete extent of this species' distribution in the Edwards Aquifer remains unknown (Bowles and Stanford 1997).

### Management
Because so little is known about the Edwards Aquifer diving beetle and its required habitat associations, the protection, recovery, and maintenance of the Edwards Aquifer is considered crucial for the survival of the species.

*Haideoporus texanus* (https://www.edwardsaquifer.org/habitat-conservation-plan/about-eahcp/covered-species/texas-cave-diving-beetle/)

### Surveys
Young and Longley (1976) used a mesh nylon net placed over the discharge from the artesian well at Texas State University to collect this species, and Bowles and Stanford (1997) and Gibson et al. (2008) used drift nets.

### Threats cited by USFWS (2009)
- Water drawdown
- Loss of water quality due to development

### Potential mitigation/translocation/ propagation actions
Unknown

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## Edwards Aquifer diving beetle
*Haideoporus texanus*


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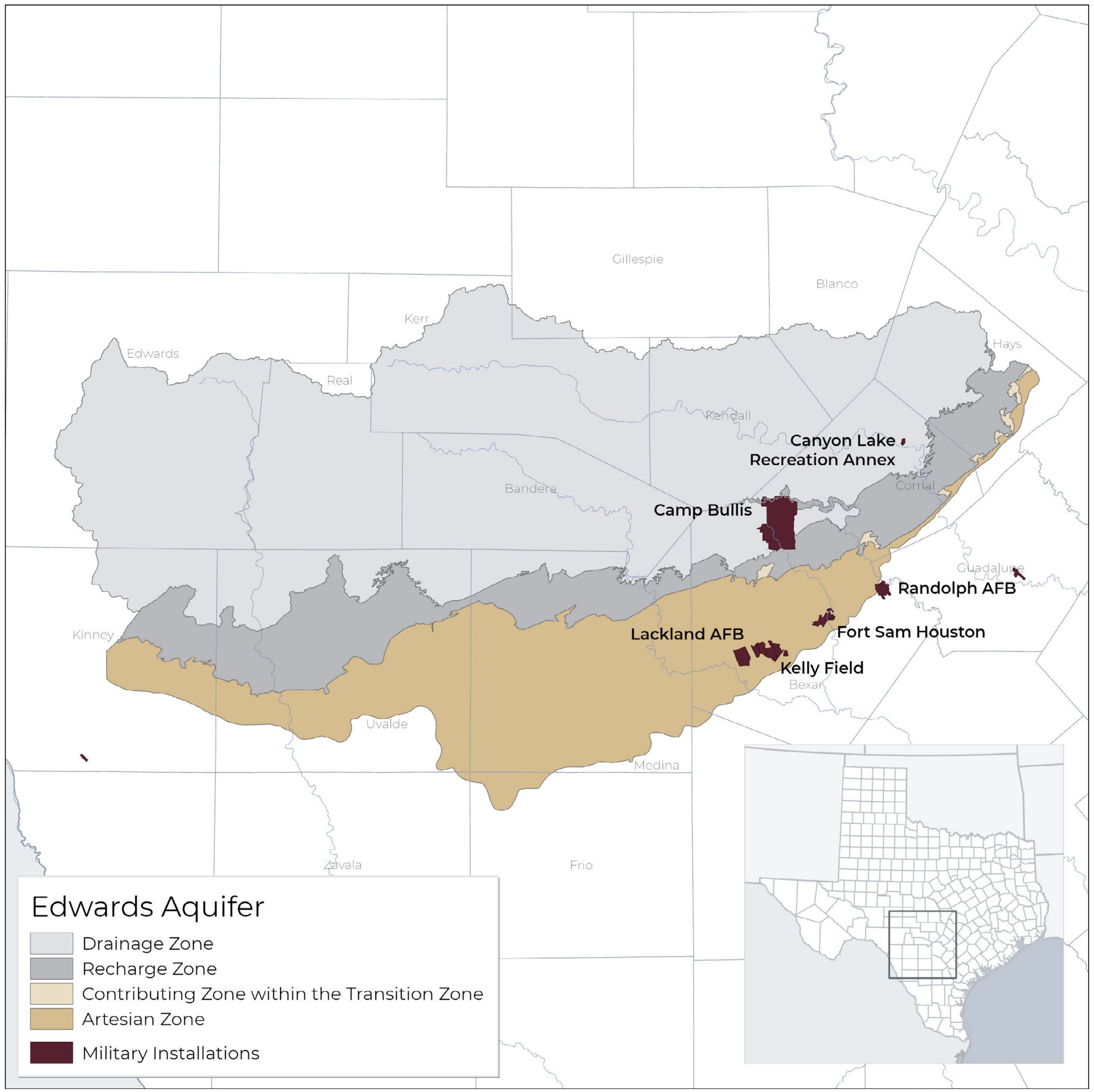
## Edwards Aquifer diving beetle
*Haideoporus texanus*




## frosted elfin butterfly
*Callophrys irus*

*Callophrys irus (James Giroux; https://www.butterfliesandmoths.org/sighting_details/1113207)*

*Callophrys irus caterpillar (b_coulter; https://www.inaturalist.org/observations/40937461)*

### ESA Status
Not listed, on current 5-year workplan for FY23. USFWS is proactively assessing the conservation status of the frosted elfin butterfly to determine whether the species warrants federal protection (USFWS 2018).

### Identification
The frosted elfin butterfly is a member of the family Lycaenidae (gossamer-winged butterflies). Gossamer-winged butterflies are generally small and have delicate wings dusted in shimmery pigmented scales. Species of the genus *Callophrys* are sedentary (non-migratory) and often occur in localized colonies. The frosted elfin is larger than most other elfin species with a 22 to 36 mm (0.9 to 1.4 in.) wingspan.

Adults are characterized by short tails that noticeably project from each hindwing. The upperside of the wings is uniform dark gray and brown in color, and the underside, while also generally grayish brown, is variegated with a dusting of pale scales on the outer margin of each hindwing and is adorned with a dark spot and an irregular dark-and-white line. Adult male wings are uniform dark brown, while female wings are dark brown basally and become orangish-brown toward the outer edges.

The larva (caterpillar) of this species, like in other gossamer-winged butterflies, is pale blue-to-green (though yellow in Oklahoma) with several white lines down the back and one along each side of the body with oblique white dashes in between each (Schweitzer et al. 2011; USFWS 2018; Wisconsin Department of Natural Resources [WDNR] 2020).

### Habitat
Xeric open habitats maintained by disturbance, such as oak-pine barrens, oak savannahs, prairie and dry oak woodlands, and sandhills, as well as anthropogenic habitats such as powerline cuts, railways, old sand/gravel pits, and airports. In general, habitats must have an open understory and a heterogeneous mix of open and closed canopy and edges and support populations

### Habitat cont.
of larval host plants (i.e., wild lupine [*Lupinus perennis*], wild indigo [*Baptisia* spp.]) (Albanese et al. 2007, 2008; Thom 2013; USFWS 2018; Shepard et al. 2021).

### Distribution
Northeastern United States south to Florida and west to Texas and Wisconsin. In Texas, east of and including Dallas and north of and including Houston.

### Management
Because frosted elfins depend on early successional habitats that support host plants, maintenance and restoration of these habitats are key to the species' conservation (USFWS 2018). Managing for early successional habitats can be done in a variety of ways, such as with prescribed fire or mechanical cutting, but considerations must be taken for all life stages of the frosted elfin, as they are present year-round in host plant patches. For this reason, it is recommended that management units be rotated so that there is always habitat available for the species. Additionally, prescribed fire has the potential to severely impact frosted elfin populations; unintensive management options such as late-season mowing and selective tree removal could be viable alternatives (Wagner et al. 2003; Swengel and Swengel 2007; Pfitsch and Williams 2009; Thom et al. 2015; Selfridge et al. 2019). However, further studies on microhabitat selection across the frosted elfin's range are needed to determine how best to manage for the species in different locations.

### Surveys
Butterflies in general can be surveyed for and monitored using a variety of methods, including trapping and netting, mark-recapture, transects (Pollard walks), and distance sampling (see Pollard 1977, Swengel 2011, Taron and Ries 2015, Kral et al. 2018). For frosted elfins specifically, surveying for caterpillars using ultraviolet flashlights at night and using camera traps to identify adults in flight are also options (McElveen and Meyer 2020; Moskowitz 2020).

### Stressors cited by USFWS (2018)
- Effects of small population size
- Habitat loss or degradation from development
- Invasive plant species
- Succession
- Incompatible management resulting in habitat fragmentation




## frosted elfin butterfly
*Callophrys irus*


### Potential mitigation/translocation/propagation actions
Translocation could potentially be an option for this species (Meyer and McElveen 2021).

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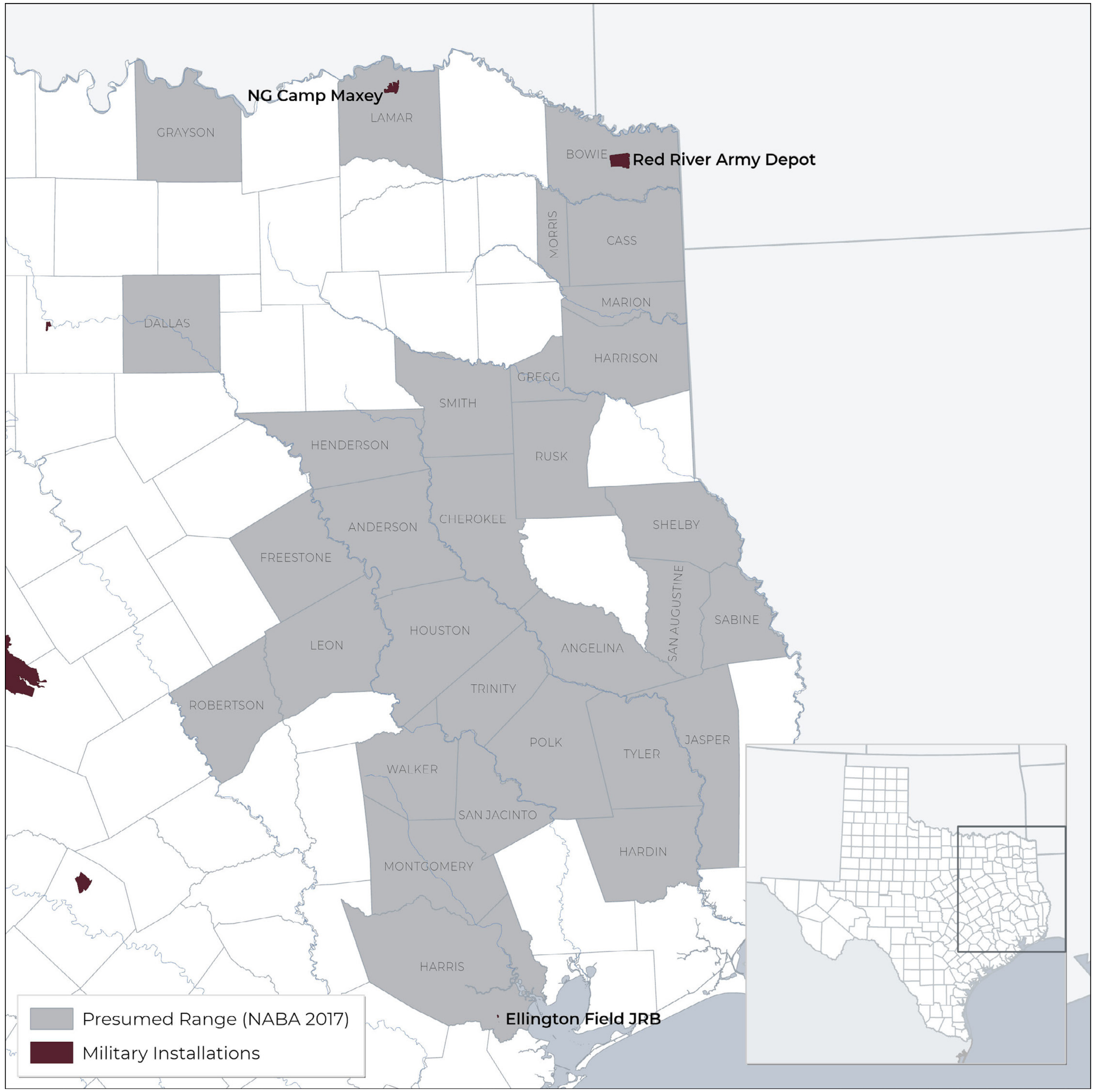
## frosted elfin butterfly

*Callophrys irus*




## monarch butterfly

*Danaus plexippus*

### ESA Status

Listed as candidate 17 December 2020.

### Identification

Monarch adults (butterfly), larvae (caterpillar), and pupae (cocoon, or chrysalis) are easily recognizable, but are similar in appearance to other closely related species and mimics, including the queen butterfly (*Danaus gilippus*), the soldier butterfly (*D. eresimus*), and the viceroy butterfly (*Limenitis archippus*) (Western Monarch Milkweed Mapper 2021). Monarch adults exhibit dark bold and easily recognizable black lines on both the underside and upperside of the wings, while queens do not have lines on the upperside, soldiers have faint lines, and viceroys have characteristic horizontal black lines crossing the wing veins. Monarch larvae have two sets of antennae (one set on either end of the body), while queen and soldier larvae have three; viceroy larvae are not similar in appearance.

### Habitat

Adult monarchs require nectar sources, and if breeding also require milkweed (*Asclepias* spp.). In general, these can be found in open areas, such as grasslands, open woodlands, shrublands, open wetlands, fields, meadows, roadsides, and gardens.

*Danaus plexippus (Tom Koerner; USFWS; https://www.fws.gov/news/blog/index.cfm/2016/11/18/Conserving-Monarch-Butterflies-in-a-Changing-Climate)*

*Danaus plexippus caterpillar (Monika Maeckle; https://texasbutterflyranch.com/2013/04/05/how-to-raise-monarch-butterflies-at-home/)*

### Distribution

The monarch butterfly can be found across almost all of North America and occurs throughout the state of Texas. It is migratory, however, and does not overwinter in Texas. In most of the state, monarchs breed only in the spring; in western Texas they also breed in summer. Monarchs also migrate through Texas in spring and fall.

### Management

Protect, restore, enhance, and create habitat. From USDA Forest Service (2015):

- Reduce forest stand densities to allow for development of herbaceous understory, which includes host and nectar plants.
- Accelerate restoration of prairies, savannahs, and woodlands on appropriate sites.
- Develop local monarch-friendly seed mixes for restoration efforts, soil stabilization, wildlife openings, and other resource opportunities.
- Manage the landscape to provide host and nectar sources from spring to fall.
- Maximize benefits to monarch butterflies without compromising their safety by controlling the timing of mowing wildlife openings and roadsides (best mowing time is in late winter).
- Time prescribed burning so that it does not coincide with migration. This approach is extremely important in [Texas], where first-generation monarch butterflies migrate north and last-generation monarch butterflies migrate south into Mexico.
- Accelerate efforts to control nonnative invasive plant species to increase abundance and diversity of butterflies and native bees.
- Develop local milkweed seed production areas.
- Reduce the amount of grass mowed by establishing pollinator gardens at administrative and recreation sites. Ensure that interpretation signs are provided at these pollinator gardens for better public understanding.

### Surveys

Butterflies in general can be surveyed for and monitored using a variety of methods, including trapping and netting, mark-recapture, transects (Pollard walks), and distance sampling (see Pollard 1977, Swengel 2011, Taron and Ries 2015, Kral et al. 2018). For monarchs specifically, milkweed surveys can be conducted and individual plants can then be monitored for monarch eggs and larvae.

### Threats cited by USFWS (2020)

- Loss and degradation of habitat from conversion of grasslands to agriculture
- Widespread use of herbicides
- Logging/thinning at overwintering sites in Mexico
- Senescence and incompatible management of overwintering sites in California
- Urban development
- Drought
- Exposure to insecticides
- Effects of climate change





### Potential mitigation/translocation/propagation actions

The captive rearing and release of monarchs by commercial breeders and hobbyists wishing to sell for release and/or contribute to dwindling population numbers is a cultural phenomenon across North America. However, captive breeding and release can have negative impacts on the species by disrupting critical natural aspects of its migratory behavior. Therefore, captive-bred monarchs should be locally sourced and reared outdoors, giving them a better chance at successful migration (Tenger-Trolander et al. 2019).

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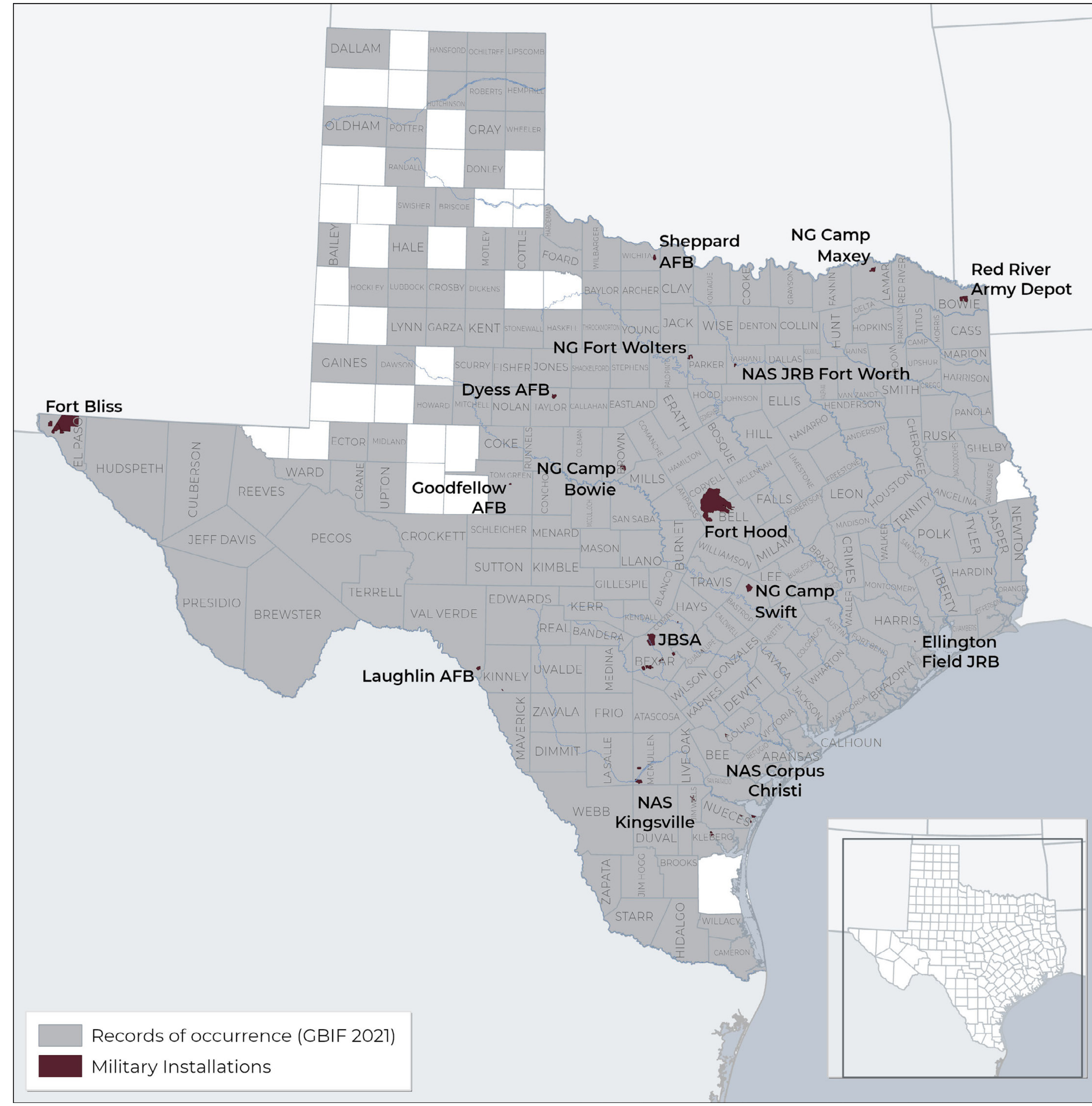

# Mammals

plains spotted skunk
Texas kangaroo rat
tricolored bat

## plains spotted skunk

*Spilogale putorius interrupta*

### ESA Status

Under review, on current 5-year workplan for FY23. In 2012, USFWS found that listing the subspecies may be warranted. *Note*: a new study has provided evidence for the elevation of the plains spotted skunk to species level. However, the associated manuscript, titled "Phylogenomic systematics of the spotted skunks (Carnivora, Mephitidae, Spilogale): Additional species diversity and Pleistocene climate change as a major driver of diversification" by McDonough et al. is still in review so we refer to the plains spotted skunk as a subspecies in this account (https://doi.org/10.1101/2020.10.23.353045).

### Identification

The spotted skunk is a small skunk with small white spots on the forehead and ears, the latter often confluent with dorsolateral white stripes along the flanks. There are six distinct white stripes on the anterior half of the body: a ventrolateral pair beginning at the back of each foreleg, a lateral pair beginning at the ear spots, and a narrow dorsolateral pair beginning at the back of the head. The posterior half of the body is characterized by two interrupted white bands, a pair of white spots on either side of the rump, and two additional white spots at the base of the tail. The animal's tail is black, like the rest of its coloration, minus a small terminal tuft of white. The ears are small and round, and sit low on either side of the animal's

*Spilogale putorius interrupta (Clint Perkins; https://txmn.org/elcamino/files/2018/05/Conservation-status-of-plains-spotted-skunk-Clint-Perkins.pdf)*

head. Each foot has five toes, and the front claws are more than double the length of those on the back. Males are larger than females (Schmidly and Bradley 2016).

The plains spotted skunk is distinguished from other subspecies of spotted skunk by its unique distribution as well as its striping pattern; the plains subspecies exhibits the thinnest white stripes and the smallest forehead spot of the subspecies and is characterized by the reduction or absence of white at the terminal end of the tail (Dowler et al. 2017).

### Habitat

Habitat associations of the spotted skunk across its range are considerably varied and few studies have provided detailed assessments of habitat characteristics (Dowler et al. 2017; Eastern Spotted Skunk Cooperative Study Group [ESSCSG] 2018). Historically, the species was associated with agricultural and semi-urban land, many times with dens in and around barns and other such buildings (Crabb 1948; Dowler et al. 2017; ESSCSG 2018). In Texas, the plains spotted skunk is anecdotally known from wooded areas and prairies where it is thought to be associated with rocky canyon and outcrops (Schmidly and Bradley 2016; Dowler et al 2017).

## plains spotted skunk

*Spilogale putorius interrupta*

### Habitat cont.

Dens appear to be a critical habitat component for the species overall and could be a limiting factor in abundance and distribution where it is known to occur. In natural areas, spotted skunks use preexisting protective cover as den sites including, but not limited to, debris piles, unused wildlife burrows, tree cavities, hollow logs, and stumps (Crabb 1948; Kinlaw et al. 1995). Near urban to semi-urban landscapes, dens are known to be under and within buildings (e.g., barns, storage sheds) or under stacked wood piles such as firewood or burn piles (ESSCSG 2018).

To date, specific habitat associations have yet to be extensively studied in Texas (Dowler et al. 2017, but see Jefferson 2021). TPWD's Rare, Threatened, and Endangered Species of Texas database (2021) defines spotted skunk habitat as "open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie."

### Distribution

The plains spotted skunk is known from west of the Mississippi River and east of the Rocky Mountains from Texas to Minnesota. In Texas, the subspecies occurs within the eastern half of the state, westward into the Edwards Plateau and through north-central Texas up to the panhandle (Schmidly and Bradley 2016).

### Management

Conservation management strategies for the subspecies have not yet been identified. A firmer understanding of distribution, abundance, and habitat associations is needed in order to better inform management practices specific to the plains spotted skunk.

### Surveys

Live traps, game cameras, and track plates are all commonly used survey techniques. Hackett et al. (2007) suggested that surveys be conducted between late September and early May, and that track plates were more efficient than camera traps at detecting spotted skunks. A manuscript titled "An evaluation of detection methods for the plains spotted skunk" by Perkins et al. is in review for publication in the Wildlife Society Bulletin.



## plains spotted skunk

*Spilogale putorius interrupta*

### Threats cited by USFWS (2012)

- Historical and currently ongoing habitat loss and degradation due to modifications of early successional habitat
- Excessive predation that may be occurring at a higher rate than naturally expected

### Potential mitigation/translocation/propagation actions

Unknown

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## plains spotted skunk
*Spilogale putorius interrupta*

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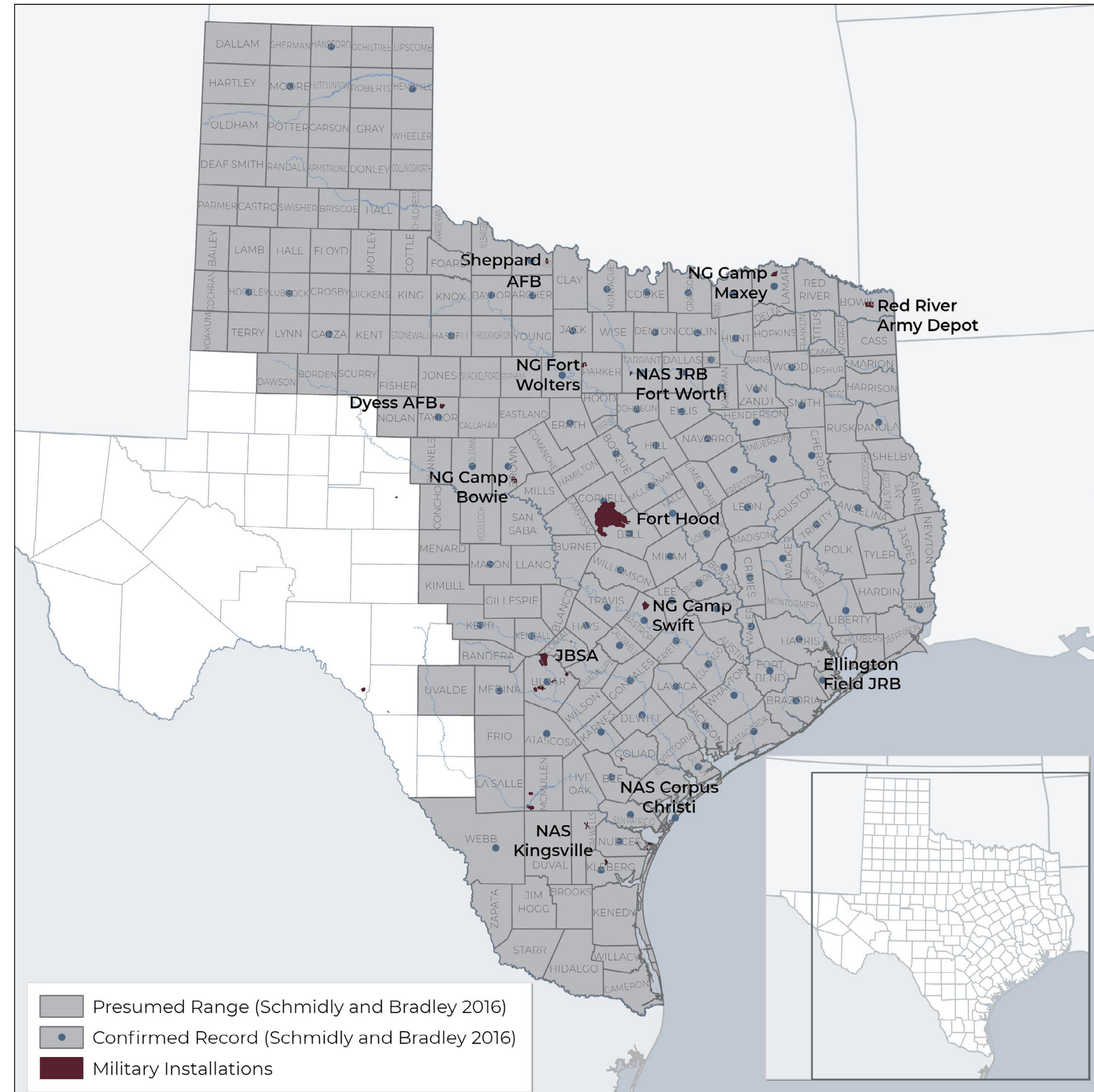
## plains spotted skunk
*Spilogale putorius interrupta*



# Texas kangaroo rat

*Dipodomys elator*

### ESA Status

Under review, on current 5-year workplan for FY21. In 2011, USFWS found that listing the species may be warranted.

### Identification

The Texas kangaroo rat is a large (~121 mm [4.76 in.] in length), four-toed rodent with a conspicuous white banner on the tip of a long (estimated to be ~162% of the body length), relatively thick tail. The upperparts of the species are buffy-to-pinkish brown, washed with blackish coloration, while the underparts are white. The Texas kangaroo rat superficially resembles the banner-tailed kangaroo rat (*Dipodomys spectabilis*), but cranial differences readily separate them, and their distributions are disjunct (Schmidly and Bradley 2016). It can be distinguished from the Ord's kangaroo rat (*D. ordii*; the only other kangaroo rat that is known to overlap historical geographical ranges with the Texas kangaroo rat) by its four-toed hind feet (USFWS 2016).

### Habitat

Although some information regarding habitat affinities is available in the literature, little is known about habitat characteristics that are important to the distribution and abundance of the Texas kangaroo rat (Stuhler et al. 2019). Loam has long been considered an important component of the species' habitat across its known historical distribution (Stuhler et al. 2019); clay likely provides structural support for burrows (Ott et al. 2019). In the past, the Texas kangaroo rat was associated with juniper-mesquite (*Juniperus-Prosopis*) shrubland/woodland, but recent literature suggests that these habitat types may only be selected for if also characterized by up to 50% bare ground interspersed with primarily grassy vegetation (Ott et al. 2019; Stuhler et al. 2019). Studies have also indicated that the species is positively associated with cropland along roadsides, but these areas are likely not utilized as permanent residences (Ott et al. 2019; Stuhler et al. 2019), and the species likely does not use the interior of agricultural lands (Goetze et al. 2008).

*Dipodomys elator (Stuhler et al. 2019)*

The Texas kangaroo rat may select for mix-grass and shortgrass prairie, though these habitat types may be avoided (even when overlayed with clay loam to loamy soils) if ground-level vegetation is too dense (Ott et al. 2019). TPWD's Rare, Threatened, and Endangered Species of Texas database (2021) defines Texas kangaroo rat habitat as "sandy loam surface soils containing some clay and which supports short grasses (buffalo grass) and small to medium sized mesquite; mesquite not required, but mostly in association with scattered mesquite shrubs and sparse, short grasses in areas underlain by firm



# Texas kangaroo rat

*Dipodomys elator*

### Habitat cont.

clay soils; along fencerows adjacent to cultivated fields/roads; burrows into soil with openings usually at base of mesquite or shrub." Open areas and raised bare ground are important habitat features (Stuhler et al. 2019).

### Distribution

According to historical collection records, the Texas kangaroo rat has a historically small, and currently shrinking, endemic range consisting of two counties (Comanche and Cotton) in southern Oklahoma where the state meets the north-central Texas border and 11 adjacent Texas counties (Motley, Cottle, Childress, Foard, Hardeman, Wilbarger, Baylor, Wichita, Archer, Clay, and Montague) (Ott et al. 2019; Stuhler et al. 2019). Assessment surveys to detect the species over the last few decades (Jones et al. 1988; Martin 2002; Nelson et al. 2013) have shown evidence of range decline to the state of Texas alone. Currently, the range of the Texas kangaroo rat is considered to be from Motley to Montague counties (Schmidly and Bradley 2016; USFWS 2016), though recent surveys conducted from 2015 to 2017 only detected the species in Cottle, Childress, Hardeman, Wilbarger, and Wichita counties (Ott et al. 2019; Stuhler et al. 2019).

### Management

Management strategies for the Texas kangaroo rat are primarily habitat focused. Restoration practices such as prescribed burns and increased grazing pressure may benefit the species by opening up bare ground, especially where suitable soil types are present. Additionally, the maintenance of unpaved roads could benefit the species as raised bare ground is often created in the process, which could promote burrowing behavior (Stuhler et al. 2019). Stuhler et al. (2019) also recommended reducing vegetation cover between roads and adjacent fields to encourage dispersal between parcels of suitable habitat.

### Surveys

Surveys for species detection have historically centered on road-driving, where species experts and researchers have driven unpaved county-maintained roads at night at slow speeds while using a light source such as the vehicle headlights or headlamps and spotlights to visually scan the road surface and roadside for Texas kangaroo rat activity (Martin and Matocha 1972; Jones et al. 1988; Martin 2002; Ott et al. 2019; Stuhler et al. 2019). Road-based surveys are simple, cover a large area in a small amount of time, and previous experience is not required as long as the

## Texas kangaroo rat

*Dipodomys elator*

### Surveys cont.

species can be readily identified. Surveys related to demographic information are better conducted with the use of Sherman live traps and require experienced and permitted individuals.

### Threats cited by USFWS (2011)

- Loss of burrowing habitat
- Genetic isolation of populations due to the conversion of native rangeland to agricultural cropland
- Inadequacy of existing regulatory mechanisms to protect against such land conversion

### Potential mitigation/translocation/propagation actions

Unknown

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## Texas kangaroo rat

*Dipodomys elator*

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## Texas kangaroo rat
*Dipodomys elator*


## tricolored bat
*Perimyotis subflavus*

### ESA Status
Under review, on current 5-year workplan for FY21. In 2017, USFWS found that listing the species may be warranted.

### Identification
The tricolored bat is a small pale yellow-to-reddish brown bat characterized by the leading edges of the wing and of the membrane between the hind legs (known as the uropatagium) being much paler in color than the rest of the bat's patagia (membranous structure). The pelage of the animal is grizzled and individual hairs are tricolored: they are dark basally, grayish-yellow medially, and dusky at the terminal tips. The tricolored bat can also be identified by its blunt tragus (fleshy projection of the animal's ear) and the length of its forearm, which averages 35 mm (Schmidly and Bradley 2016; Minnesota Department of Natural Resources [MNDNR] 2021).

### Habitat
Generally, tricolored bats roost in caves, cliff crevices, and various anthropogenic structures. However, during the summer, reproductive females form maternity colonies which are usually in trees, and males and non-reproductive females have been observed roosting singly in trees (Carter et al. 1999; Veilleux and Veilleux 2004). In Texas, extensive colonies of wintering tricolored bats occur in the eastern portion of the state, where the known majority hibernate in culverts,

*Perimyotis subflavus* (Rick Clawson; https://djcase.com/team/rick-clawson)

though some also use natural cave hibernacula (Bernard et al. 2019; Leivers et al. 2019). During foraging, the species frequents open water and is closely associated with woodlands, particularly in the more eastern stretches of its geographical range.

### Distribution
Eastern half of North America. In Texas, the tricolored bat is most commonly known throughout much of the eastern and central half of the state, and recent records in Presidio and Brewster counties in the Trans-Pecos and Lubbock County in the southern panhandle suggest a westward expansion of its range (Schmidly and Bradley 2016).

### Management
Tricolored bats are highly susceptible to white-nose syndrome (WNS), a disease caused by the fungal pathogen *Pseudogymnoascus destructans* that affects hibernating bats. Bernard et al. (2019) assessed different management strategies to combat WNS in East Texas and found that optimal strategies differ based on several factors, including whether hibernating colonies are located in culverts or caves. Management options include spraying a chitosan treatment on bats

### Management cont.

during early hibernation, fogging roosting sites with B23 (an antimicrobial cocktail), applying polyethylene glycol 8,000 to a site when bats are not present, directly applying a vaccine treatment on bats during summer/fall, shining ultraviolet-C on individuals, spraying probiotic on bats at the beginning of hibernation, controlling the microclimate of roosts to minimize optimal growing conditions for *P. destructans,* cleaning and disinfecting roosts during summer with soap and water, chlorine dioxide, and/or pressurized steam, or a combination of treatments.

Additionally, tricolored bats are often disturbed or killed while roosting in their hibernaculum sites. Known hibernaculum sites should be gated or otherwise made inaccessible from September to June. Research on summer habitat use is needed to determine whether a lack of suitable summer habitat is impacting the species (MNDNR 2021; TPWD 2021).

### Surveys

There are many ways to survey for bats, including monitoring potential roosts, mist-netting, and acoustic monitoring. Although developed for the pacific northwest, Thomas and West (1989) provide a general summary of sampling methods for bats.

### Threats cited by USFWS (2017)

- Logging
- Natural gas development
- Mine closures
- White-nose syndrome
- Environmental contaminants
- Effects of climate change
- Wind energy operation

### Potential mitigation/translocation/propagation actions

Unknown

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tricolored bat
*Perimyotis subflavus*

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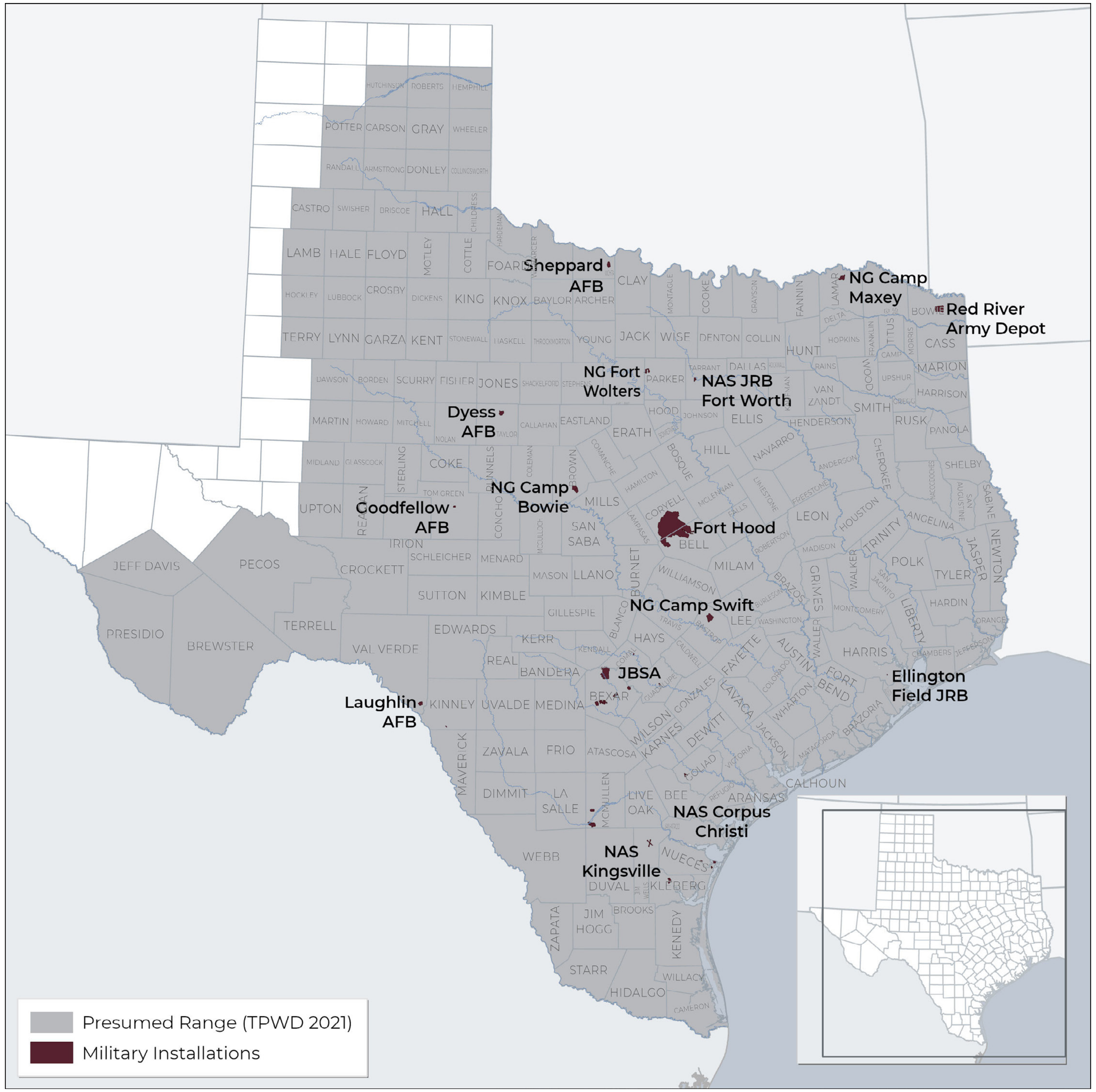
## tricolored bat
*Perimyotis subflavus*




# Mollusks

- Balcones spike
- false spike
- Guadalupe fatmucket
- Guadalupe orb
- Louisiana pigtoe
- Mexican fawnsfoot
- mimic cavesnail
- Salina mucket
- Texas fatmucket
- Texas fawnsfoot
- Texas heelsplitter
- Texas pimpleback

## false spike
## Balcones spike
*Fusconaia mitchelli* and *iheringi*

### ESA Status
Proposed endangered 26 August 2021.

### Identification
From Mussels of Texas (2020):
*Shell structure:* thin in smaller specimens but becoming moderately thick in larger individuals; compressed to moderately inflated; outline subrhomboidal to suboval; posterior ridge sharp to rounded, may show a second or third ridge; may present a shallow depression or sulcus anterior to the posterior ridge; posterior slope flat and slightly concave.

*Shell color*: yellow-green, red-brown, brown, or black; may have faint green or brown rays; surface often lightly dull to subglossy.

*Shell texture*: surface can be without sculpture or with small pustules and dorsal-to-ventral ridges that resemble small folds; may have faint ridges along the posterior slope.

*Beaks*: low and broad; umbo cavity shallow to moderately deep and slightly above hinge line.

*Beak sculpture*: some may have irregular ridges.

*Teeth*: pseudocardinal teeth thin to thick, rough, triangular, 2 divergent teeth in left valve and 1 in right valve, with a reduced and compressed anterior denticle, may have a posterior denticle that is poorly developed. Lateral teeth short to moderately long, straight to slightly curved, 2 in left valve, 1 in right valve.


*Fusconaia mitchelli – lower Guadalupe River (Guadalupe River drainage), length 46.0 mm (Mussels of Texas 2020)*

*Interdentum*: short to moderately long, narrow to wide.

*Nacre*: white, iridescent posteriorly.

*Other*: not sexually dimorphic. Soft tissues yellowish-orange with pink or red gills when gravid that may change color based on the maturity of the glochidia.

### Habitat
From Mussels of Texas (2020): Occurs in small streams to medium-sized rivers in habitats such as riffles and runs with flowing water, occasionally found in nearshore habitats such as banks and backwaters or pools. Not known from reservoirs and is intolerant of stream dewatering. Is often found in substrates comprised of sand, gravel, and cobble that are hydraulically stable (Randklev et al. 2012; Sowards et al. 2013; Tsakiris and Randklev 2016).



## false spike
## Balcones spike
*Fusconaia mitchelli* and *iheringi*

### Distribution
Endemic to the Brazos, Colorado, and Guadalupe river drainages in Texas. However, a recent study (Smith et al. 2020) provided evidence for the split of *Fusonaia mitchelli* into two distinct species: *F. mitchelli* is now considered endemic only to the Guadalupe River drainage, and *F. iheringi* (Balcones spike) characterizes the populations in the Colorado and Brazos river basins. The map displays the distribution of both species.

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address

**Surveys cont.**

detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

**Threats cited by USFWS (2021)**

- Increased fine sediment
- Changes in water quality
- Altered hydrology in the form of inundation
- Altered hydrology in the form of loss of flow and scour of substrate
- Predation and collection
- Barriers to fish movement
- Climate change

**Potential mitigation/translocation/propagation actions**

Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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## false spike
## Balcones spike
*Fusconaia mitchelli* and *iheringi*

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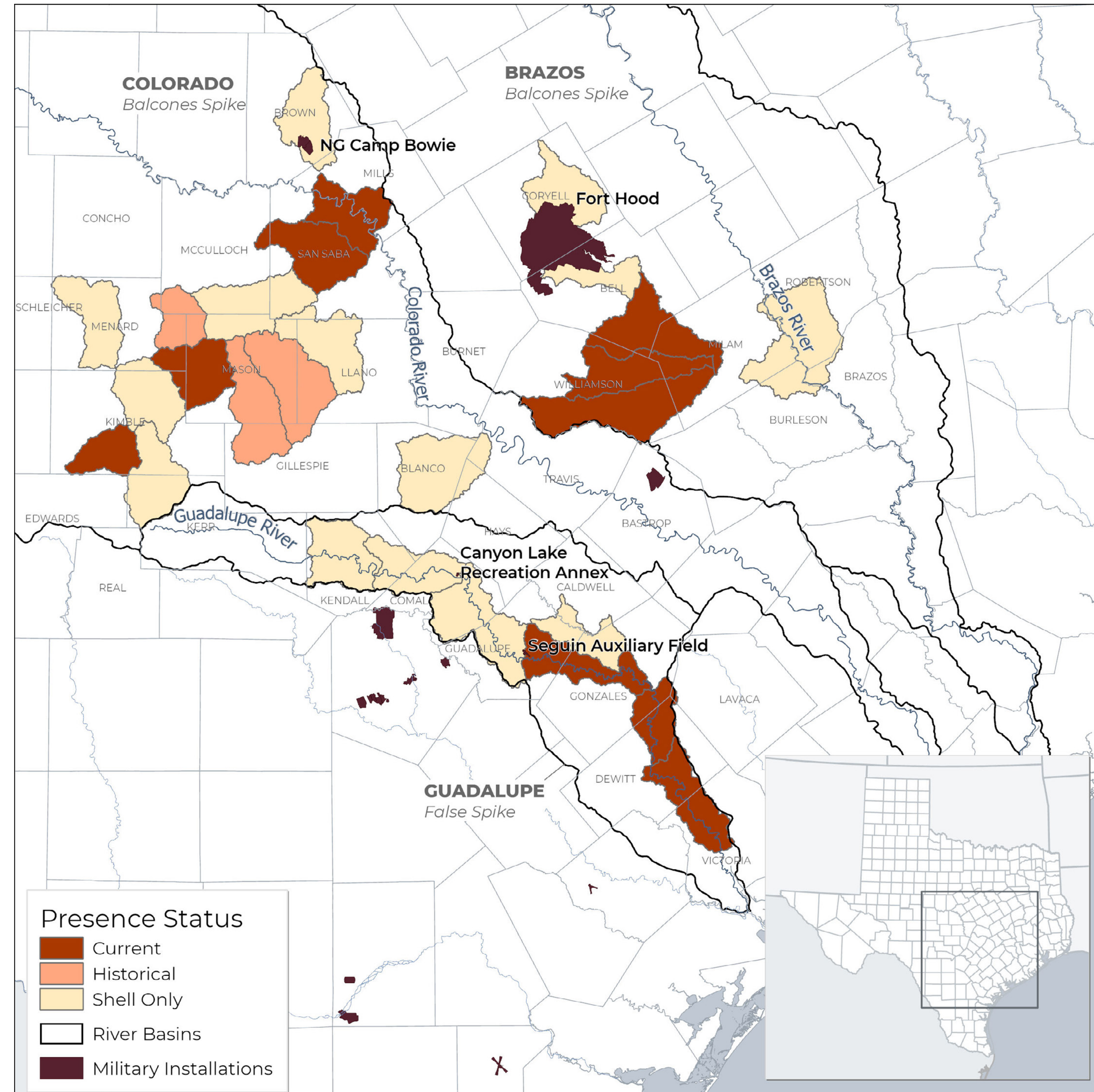

# Guadalupe fatmucket

*Lampsilis bergmanni*

### ESA Status

Proposed endangered 26 August 2021.

### Identification

From Mussels of Texas (2020):

*Shell structure:* thin to moderately thick and somewhat inflated; outline elliptical to ovate; posterior ridge broadly rounded to barely perceptible; posterior slope flat to slightly concave.

*Shell color*: yellow-green, brown-green, yellow, or brown with prominent green or black broken rays that widen towards the margin; surface subglossy to glossy.

*Shell texture*: smooth except for growth-rest lines

*Beaks*: broad and somewhat elevated above hinge line; umbo cavity shallow to moderately deep.

*Beak sculpture*: when present consists of double-looped or v-shaped ridges.

*Teeth*: pseudocardinal teeth triangular, compressed, thin, 2 teeth in left valve and 1 in right valve, occasionally with a thin accessory denticle anteriorly. Lateral teeth relatively long, thin, slightly curved, 2 in left valve, 1 in right valve.

*Interdentum*: moderately long, narrow, may be nearly absent.

*Nacre*: white or bluish-white, iridescent posteriorly; some may have a salmon or orange tint.

*Other*: sexually dimorphic, posterior margin broadly rounded to truncate in females, narrowly rounded to pointed in males; females tend to be more inflated posteriorly than males. Soft tissues white to off-white.

*Lampsilis bergmanni – holotype, top image, female, upper Guadalupe River (Guadalupe River drainage), length 57.0 mm; bottom image, male, upper Guadalupe River (Guadalupe River drainage), length 55.7 mm (Mussels of Texas 2020)*

### Habitat

From Mussels of Texas (2020): Reported to occur in slow to moderate current in sand, mud, and gravel substrates among large cobble, boulders, bedrock ledges, horizontal cracks in bedrock slabs, and macrophyte beds. Has also been observed inhabiting the roots of cypress trees and vegetation along steep banks. Reported in lakes at Kerrville, Texas, which suggests it may occasionally persist in some impoundment conditions (Robert G. Howells, personal communication), but population performance of those populations remains unknown.

### Distribution

Endemic to the Upper Guadalupe River drainage above New Braunfels, Texas.



# Guadalupe fatmucket

*Lampsilis bergmanni*

### Management

- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys

Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

### Threats cited by USFWS (2021)

- Increased fine sediment
- Changes in water quality
- Altered hydrology in the form of inundation
- Altered hydrology in the form of loss of flow and scour of substrate
- Predation and collection
- Barriers to fish movement
- Climate change

### Potential mitigation/translocation/propagation actions

Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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Guadalupe fatmucket
*Lampsilis bergmanni*

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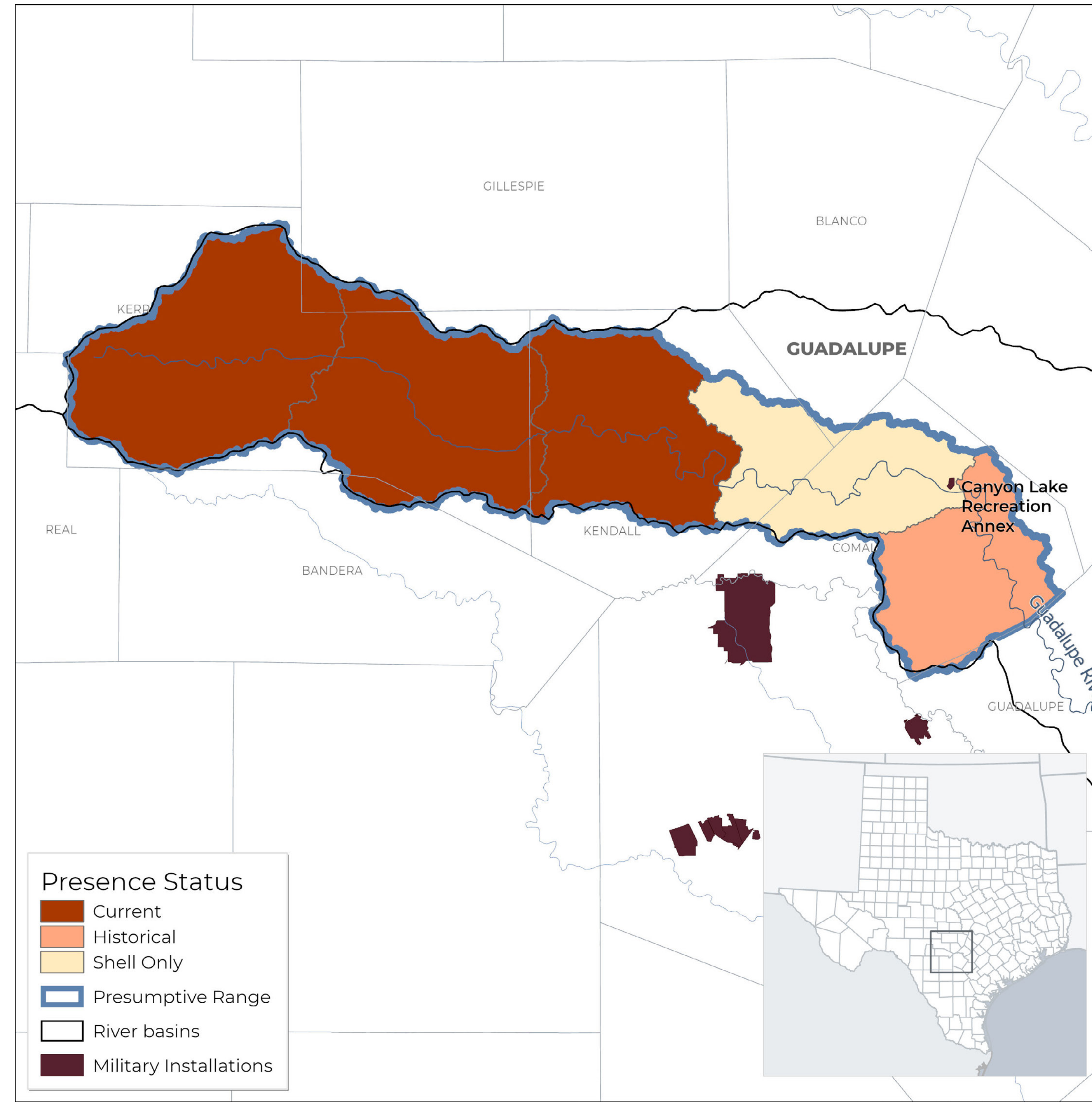
## Guadalupe fatmucket
*Lampsilis bergmanni*

**References cont.**

U.S. Fish and Wildlife Service. 2021. Endangered and threatened wildlife and plants; endangered species status with critical habitat for Guadalupe fatmucket, Texas fatmucket, Guadalupe orb, Texas pimpleback, and false spike, and threatened species status with Section 4(d) rule and critical habitat for Texas fawnsfoot. Federal Register 86:47916–48011. https://www.federalregister.gov/documents/2021/08/26/2021-18012/endangered-and-threatened-wildlife-and-plants-endangered-species-status-with-critical-habitat-for

## Guadalupe fatmucket
*Lampsilis bergmanni*



## Guadalupe orb
*Cyclonaias necki*

### ESA Status
Proposed endangered 26 August 2021.

### Identification
From Mussels of Texas (2020):

*Shell structure:* moderately to very thick and slightly to relatively inflated, but can be compressed; outline subquadrate to subovate or nearly ovate in shape; posterior ridge rounded sometimes biangulate; posterior slope flat to slightly concave, may have angular crenulations or parallel ridges. Individuals inhabiting riffles or the upper part of watersheds can produce elongated, compressed morphotypes.

*Shell color*: yellow-green, brown-green, yellow, brown, or black; may have green blotches that resemble irregular rays; surface may be dull to subglossy.

*Shell texture*: without sculpture.

*Beaks*: narrow to broad and moderately high above the hinge line; umbo cavity deep.

*Beak sculpture*: rows of ridges, which often form a distinct cross-hatching pattern.

*Teeth*: pseudocardinal teeth large, triangular, rough, divergent, 2 in the left typically with the posterior tooth being smaller than the anterior, 1 tooth in the right valve, may have accessory denticles anteriorly and/or posteriorly; lateral teeth short to moderately long, thick, and straight to slightly curved, 2 in left valve, 1 in right valve.

*Cyclonaias necki – Lower Guadalupe River (Guadalupe River drainage), length 49.2 mm (Mussels of Texas 2020)*

*Interdentum*: short, wide, and thick.

*Nacre*: white to bluish-white, iridescent posteriorly.

*Other*: not sexually dimorphic; soft tissues white to off-white.

### Habitat
From Mussels of Texas (2020): Reported from medium-size streams to large rivers primarily in riffles and runs, occasionally occurs in pools. Often found in substrates composed of sand, gravel, and cobble, including mud-silt or gravel-filled cracks in bedrock slabs. Considered intolerant of reservoirs.

### Distribution
Endemic to the Guadalupe River drainage and adjacent tributaries in Texas.

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.



## Guadalupe orb
*Cyclonaias necki*

### Management cont.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

### Threats cited by USFWS (2021)
- Increased fine sediment
- Changes in water quality
- Altered hydrology in the form of inundation
- Altered hydrology in the form of loss of flow and scour of substrate
- Predation and collection
- Barriers to fish movement
- Climate change

## Guadalupe orb
*Cyclonaias necki*

### Potential mitigation/translocation/propagation actions

Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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## Guadalupe orb
*Cyclonaias necki*

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## Guadalupe orb

*Cyclonaias necki*


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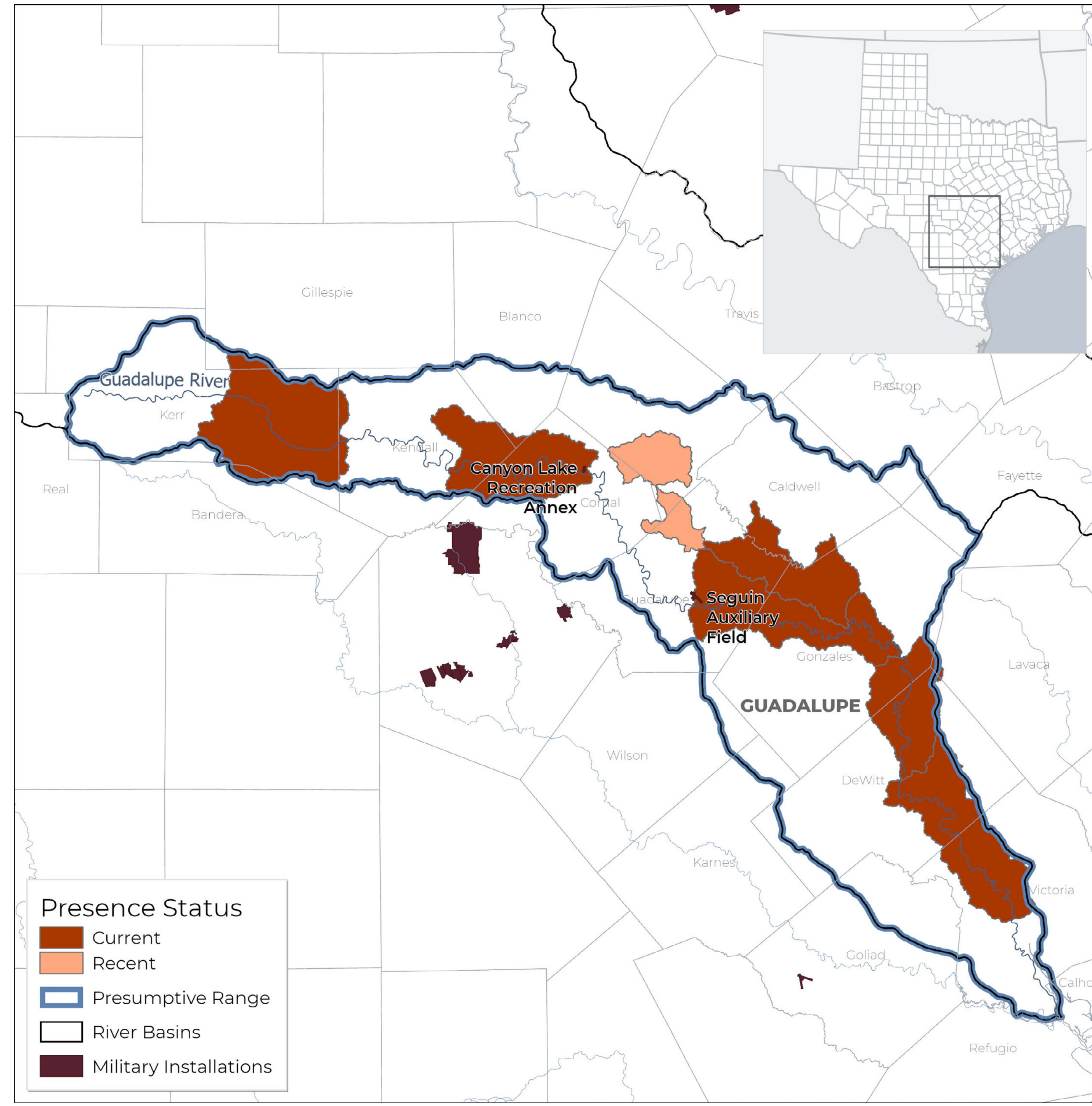
## Guadalupe orb

*Cyclonaias necki*

## Louisiana Pigtoe
*Pleurobema riddellii*

### ESA Status
Under review, on current 5-year workplan for FY20 but a decision has not been published yet. In 2009, USFWS found that listing the species may be warranted.

### Identification
From Mussels of Texas (2020):
*Shell structure:* thick and inflated; outline triangular to subquadrate; posterior ridge elevated and sharp throughout, ending at a point near the dorsal margin; posterior slope nearly flat to slightly concave.

*Shell color*: red-brown, brown, or black; surface dull to subglossy.

*Shell texture*: without sculpture except for growth-rest lines.

*Beaks*: high, broad, and elevated above the hinge line; umbo cavity deep.

*Beak sculpture*: rabsent or numerous, curved, corrugated ridges.

*Teeth*: pseudocardinal teeth triangular, thick, erect, and roughened, 2 in left valve, divergent with the posterior tooth being larger compared to the anterior, which is compressed and nearly parallel to the hinge line, 1 tooth in the right valve with a thin anterior and thick posterior denticle. Lateral teeth short, thick, and straight to slightly curved, 2 in left valve, 1 in right valve.

*Interdentum*: short and wide.

*Nacre*: white or bluish-white; iridescent posteriorly.


*Pleurobema riddellii – Village Creek (Neches River drainage), length 40.0 mm (Mussels of Texas 2020)*

*Other*: not sexually dimorphic; soft-tissues off-white or tan and does not show red or pink coloration when gravid, which is typical in *Fusconaia*.

### Habitat
From Mussels of Texas (2020): Occurs in small streams to large rivers in slow to moderate currents in substrates of clay, mud, sand, and gravel (Randklev et al. 2013; Troia et al. 2015). Not known from impoundments but has been observed in water supply canals. Is unable to cope with poor water quality and flow modification stemming from river impoundment (Randklev et al. 2013; Randklev et al. 2016; Randklev et al. 2017).

### Distribution
Mississippi River basin from Louisiana to southeastern Oklahoma and southwestern Arkansas and Gulf Coast drainages from the San Jacinto River basin in Texas to the Pearl River of western Mississippi. The map below displays its distribution in Texas, but it should be noted that its distribution potentially extends northward to the Red River drainage.

*Note:* Reports of *Pleurobema riddellii* from the Cypress and Sulphur drainages in Texas have not been molecularly confirmed and their morphology is atypical. Because of this there is the possibility that purported *P. riddellii* from



## Louisiana Pigtoe
*Pleurobema riddellii*

### Distribution cont.
these basins have been misidentified. *Quadrula friersoni* Wright 1896, described from Bayou Pierre, Red River drainage, De Soto Parish, Louisiana, historically was considered a distinct taxon closely allied with *P. riddellii*. However, recent molecular studies on *Pleurobema* throughout its range, to include the Red River drainage, have yet to confirm its existence (Inoue et al. 2018; Johnson et al. unpublished data). Within Arkansas molecular studies have demonstrated the presence of a potentially new species within *P. riddellii* (Inoue et al. 2018).

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address

**Surveys cont.**
detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

**Threats cited by USFWS (2009)**
- General human modification of the water and adjacent land
- Siltation
- Impoundments
- Water pollution

**Potential mitigation/translocation/propagation actions**
Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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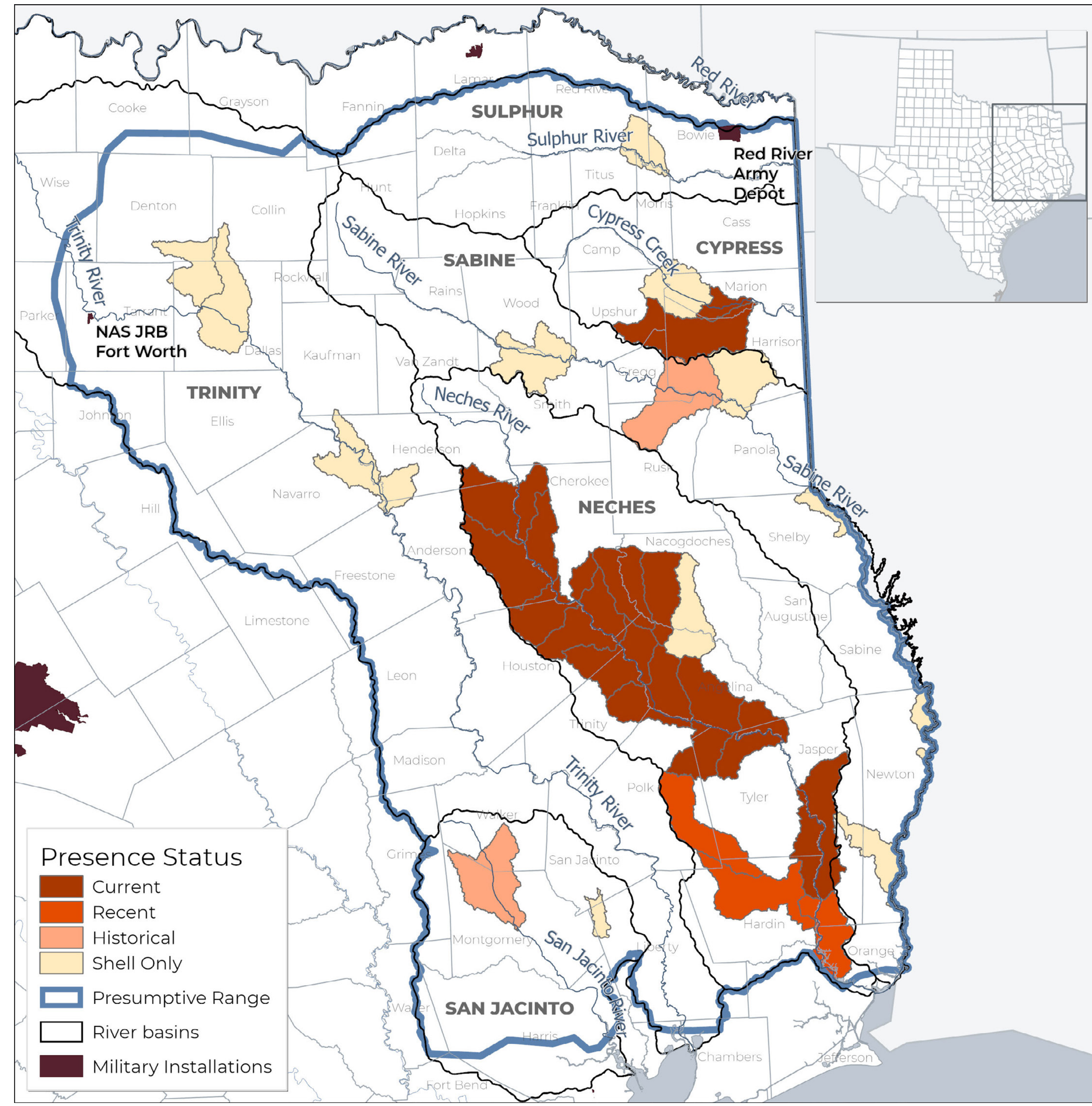

## Mexican fawnsfoot
*Truncilla cognata*

### ESA Status
Under review, on current 5-year workplan for FY22. In 2009, USFWS found that listing the species may be warranted.

### Identification
From Mussels of Texas (2020):

*Shell structure:* thin to moderately thick and slightly to relatively inflated; outline elliptical to suboval; posterior ridge sharp to rounded.

*Shell color*: yellow to greenish, rarely darker, with broken rays that occasionally show chevron-like markings; surface may be glossy to subglossy.

*Shell texture*: without sculpture.

*Beaks*: shallow to moderately deep and slightly above hinge line.

*Beak sculpture*: may have a weak pattern of 3–4 ridges.

*Teeth*: pseudocardinal teeth compressed, ragged, and triangular; lateral teeth short, thin, straight to slightly curved.

*Nacre*: white to bluish-white, iridescent posteriorly.

*Other*: faintly sexually dimorphic, posterior margin broadly rounded to slightly truncate in females, narrowly rounded to pointed in males.

### Habitat
From Mussels of Texas (2020): Occurs in large rivers but may also be found in medium-sized streams. Is commonly found in habitats with some flowing water, often in protected near shore areas

*Truncilla cognata – middle Rio Grande near Laredo, TX (Rio Grande drainage), length 44.0 mm (Mussels of Texas 2020)*

such as banks and backwaters but also at the head of riffles; the latter more often supporting both sub-adults and adults. Typically occurs in substrates of mixed sand and gravel as well as soft unconsolidated sediments. Considered intolerant of reservoirs (Randklev et al. 2018).

### Distribution
Endemic to the Rio Grande basin of Texas and northern Mexico.

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.



## Mexican fawnsfoot
*Truncilla cognata*

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

### Threats cited by USFWS (2009)
- Present or threatened destruction, modification, or curtailment of its habitat or range

### Potential mitigation/translocation/propagation actions
Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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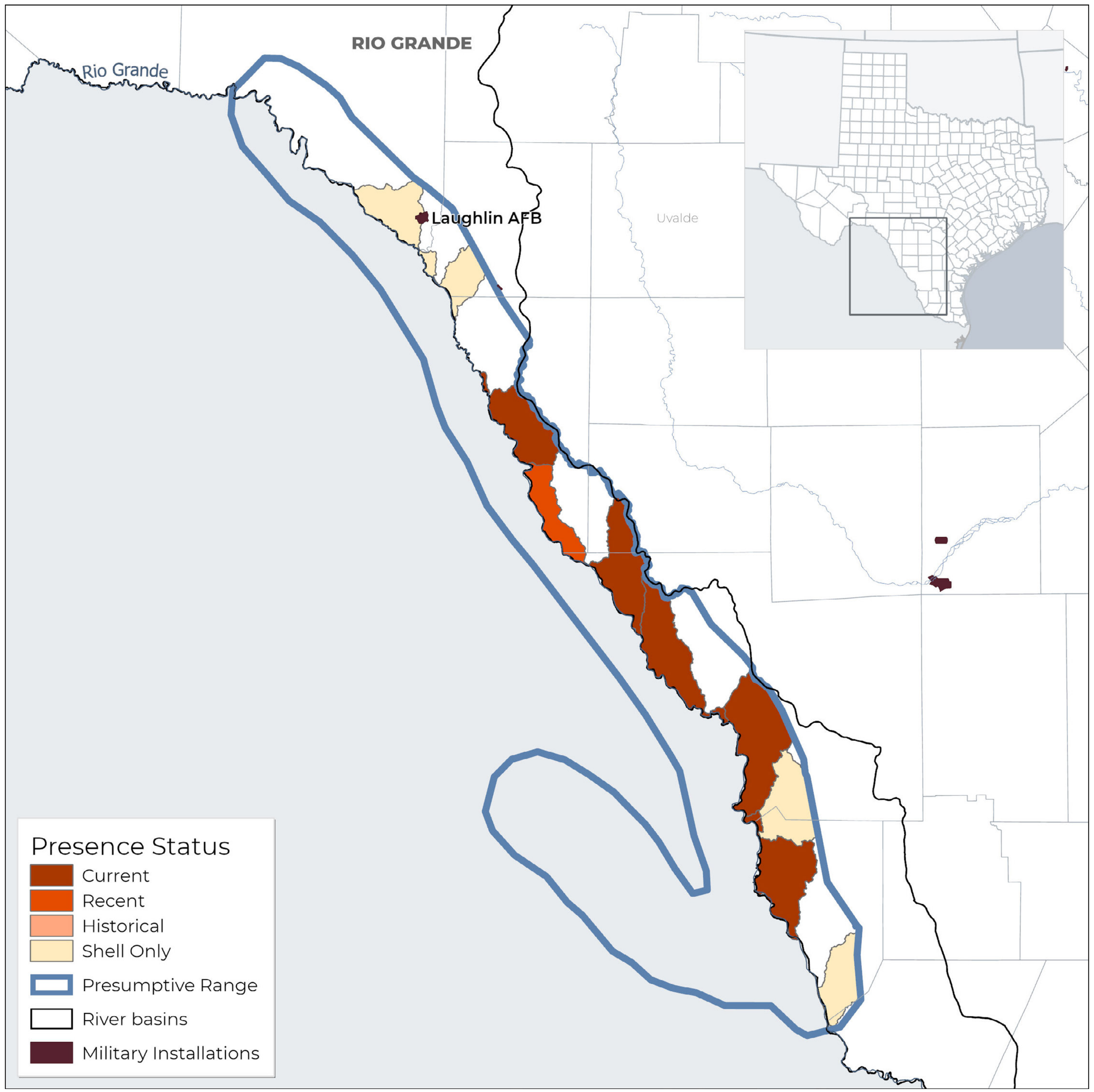
## Mexican fawnsfoot

*Truncilla cognata*




## mimic cavesnail

*Phreatodrobia imitata*

### ESA Status

Under review, on current 5-year workplan for FY22. In 2009, USFWS found that listing the species may be warranted.

### Identification

Colorless, transparent snail distinguished by its tall, conical shell; about 1 mm in height with 3.3–3.5 well-rounded whorls with deep sutures, highly flared aperture, as well as a complex intestine coil.

### Habitat

The mimic cavesnail has only been confirmed from two tightly cased wells in southern Bexar County. Therefore, its subaquatic habitat is most likely found in the aquifer's underlying deep artesian zone which can include fractures, joins, and caverns in the bedrock. It is also probably found in similar habitats in recharge zones where the aquifer is unconfined.

### Distribution

This species has only been confirmed in two well sites (i.e., Verstraeten Well and O. R. Mitchell Well) located in the Edwards (Balcones Fault Zone) Aquifer in the Von Ormy section of Bexar County, Texas. A study published in 2020 (Alvear et al.) found that there may be a new population in Hidden Spring no. 2 in Bell County, Texas with slight variations in the sculpture pattern. This population could represent a large range expansion for the species but has not been confirmed


*Phreatodrobia imitata, apertural view (1.13 mm length; Verstraeten Well, Bexar County, Texas; Alvear et al. 2020)*

because there were no soft tissues present to examine internal anatomical features.

### Management

Mimic cavesnail populations would benefit from consistent groundwater conservation, protection from contamination, and responsible extraction (e.g., industrial use for oil and gas, human consumption).

### Surveys

Mimic cavesnails have been sampled from artesian wells using fine-mesh funnel nets attached to outflow pipes with hose clamps. The samples at the end of the net were collected in either a 3.8-L plastic jar or small section 64-µm mesh netting material clamped to a section of PVC pipe with a screw-on cap. Collected individuals were preserved in 70–95% ethanol or isopropanol. Wells can also be sampled with funnel traps fashioned from empty 1-L water bottles by cutting off the top and inverting it into the body of the bottle. These traps can then be baited with pistachios and cotton substrate. See Hershler and Longley 1986, Nissen et al. 2018, and Alvear et al. 2020 for more information.

### Threats cited by USFWS (2009)

- Groundwater withdrawal
- Groundwater contamination

### Potential mitigation/translocation/propagation actions

Although no studies have investigated potential mitigation, translocation, and propagation actions for the mimic cavesnail, they are likely not viable management options because the species is so narrowly endemic and has only been found in inaccessible portions of the aquifer's deep artesian zones.

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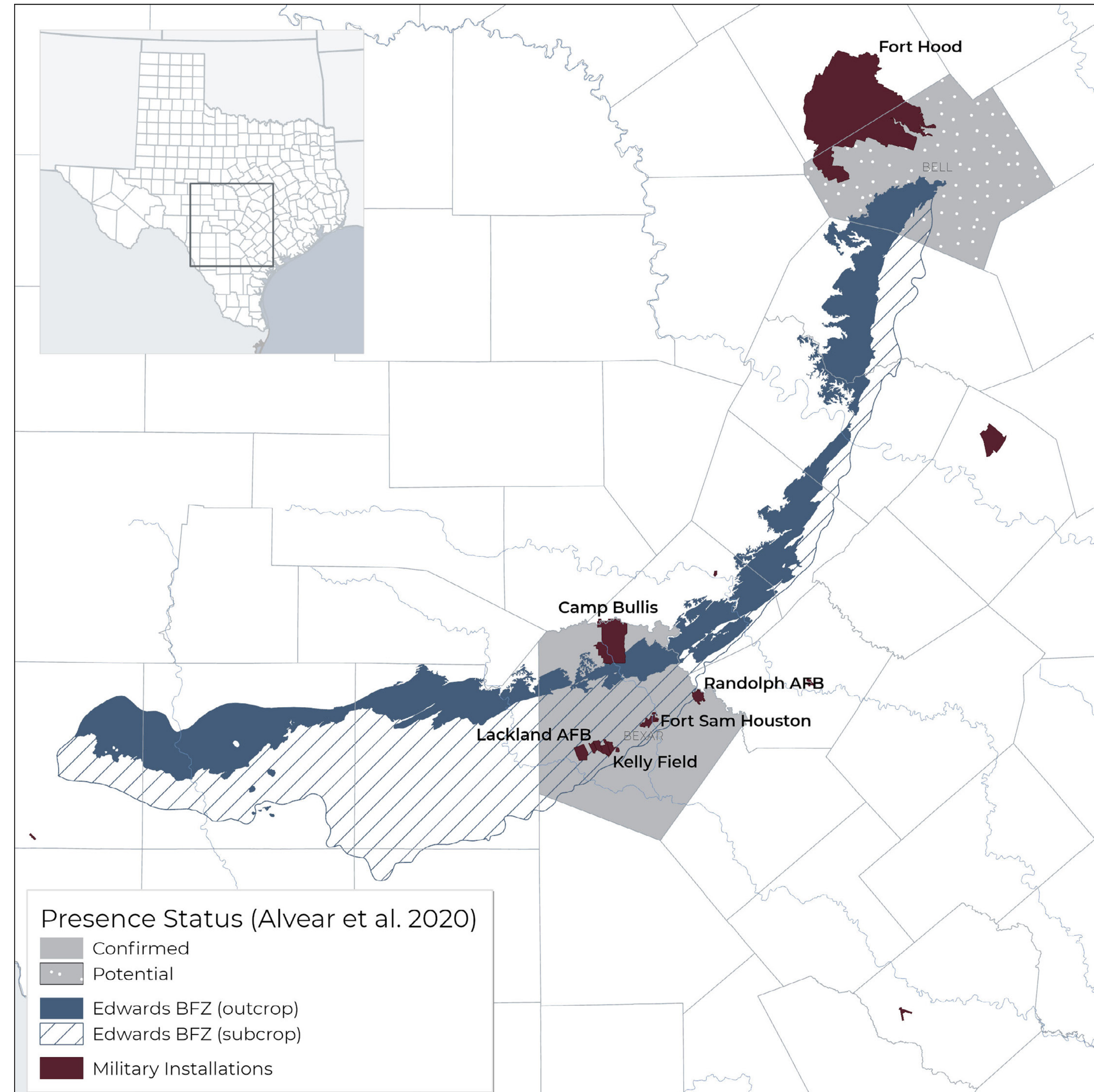
mimic cavesnail
*Phreatodrobia imitata*



## Salina mucket
*Potamilus metnecktayi*

### ESA Status
Under review, on current 5-year workplan for FY22. In 2009, USFWS found that listing the species may be warranted.

### Identification
From Mussels of Texas (2020):
*Shell structure:* moderately thick to thick, somewhat inflated; outline rather ovate, may have a low dorsal wing posterior to the umbo; posterior ridge broadly rounded; posterior slope flat to slightly concave, merging with dorsal wing when present.

*Shell color*: tan, brown, or black; may have green markings or faint rays; surface may be dull to subglossy.

*Shell texture*: smooth except for growth-rest lines.

*Beaks*: low, broad and elevated slightly above the hinge line; umbo cavity shallow.

*Beak sculpture*: unreported.

*Teeth*: pseudocardinal teeth triangular, erect, moderately thick, 2 in the left, somewhat divergent, 1 tooth in the right valve, usually with a small anterior denticle. Lateral teeth relatively short, moderately thick, slightly curved, 2 in left valve, 1 in right valve.

*Interdentum:* long and narrow.

*Nacre*: white to bluish-white; iridescent posteriorly.

*Other*: sexually dimorphic, females broadly rounded to truncate, males more pointed or narrowly rounded. Soft tissues are white to tan.

*Potamilus metnecktayi – top image, female, Lower Canyons of the Rio Grande (Rio Grande drainage), length 67.0 mm; bottom image, male, Lower Canyons of the Rio Grande (Rio Grande drainage), length 115.0 mm (Mussels of Texas 2020)*

### Habitat
From Mussels of Texas (2020): Occurs in large rivers, where it may be found in still to moderate currents in substrates composed of various combinations of mud, sand, and gravel. Also, can occur under large rocks and amongst boulders. It primarily occurs in nearshore habitats such as banks and backwater pools. It is not found in highly disturbed environments and is not known from reservoirs. Its absence from reaches downstream of large reservoirs on the Rio Grande indicate it may not be able to cope with flow modification stemming from river impoundment (Randklev et al. 2018).

### Distribution
Endemic to the Rio Grande drainage of Texas and Mexico.

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.



## Salina mucket
*Potamilus metnecktayi*

### Management cont.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

### Threats cited by USFWS (2009)

- Present or threatened destruction, modification, or curtailment of its habitat or range

### Potential mitigation/translocation/propagation actions

Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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## Salina mucket
*Potamilus metnecktayi*

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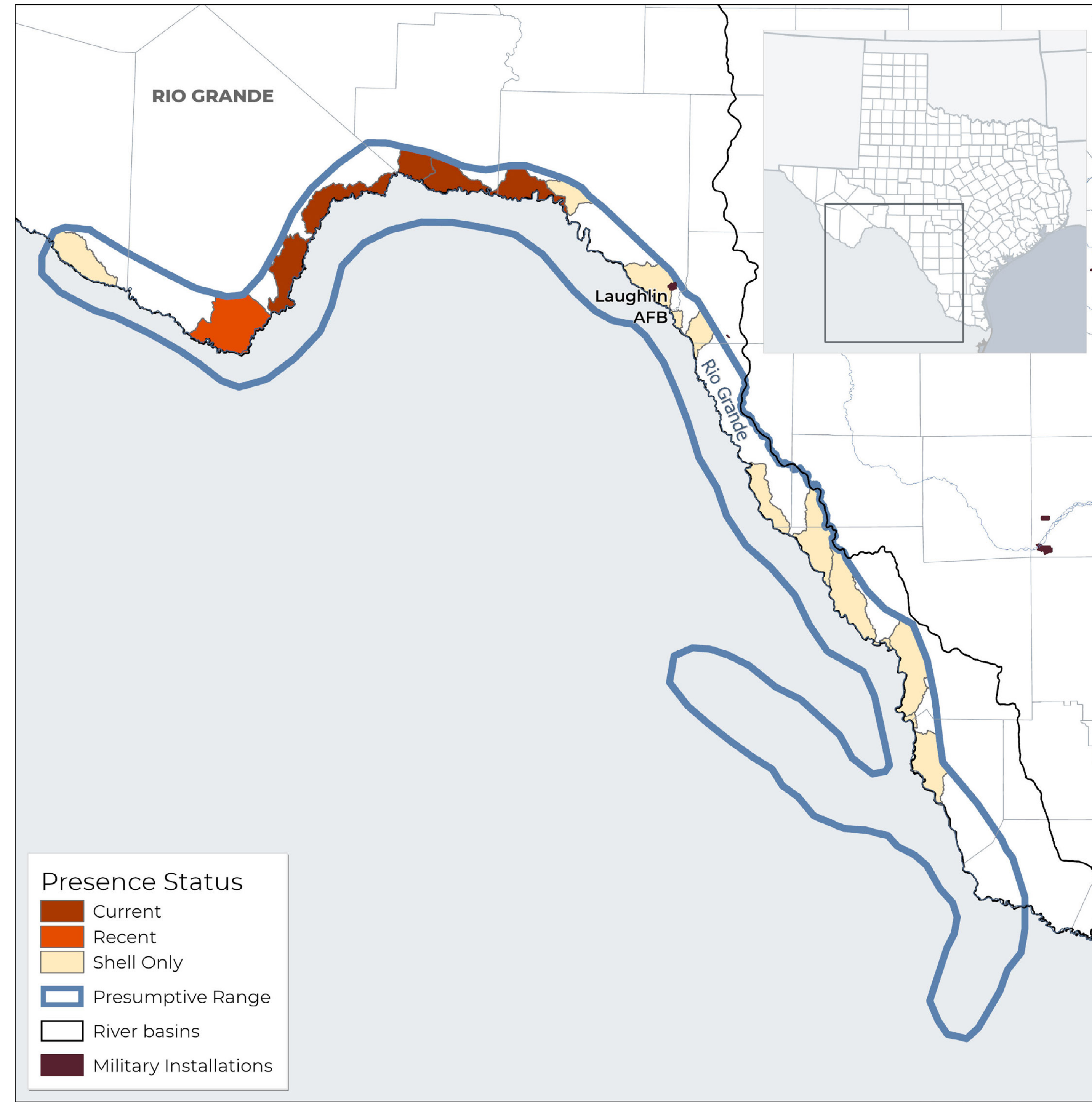
## Salina mucket
*Potamilus metnecktayi*



## Texas fatmucket
*Lampsilis bracteata*

### ESA Status
Proposed endangered 26 August 2021.

### Identification
From Mussels of Texas (2020):

*Shell structure:* thin to moderately thick, somewhat inflated; outline elliptical to ovate; posterior ridge low and broadly rounded to barely perceptible; posterior slope flat to slightly concave.

*Shell color*: yellowish-green, brownish-green, or brown; presents prominent, wavy, green or black broken rays that widen towards the margin; surface subglossy to glossy.

*Shell texture*: smooth except for growth-rest lines.

*Beaks*: low, broad and elevated above the hinge line; umbo cavity shallow to moderately deep.

*Beak sculpture*: absent or consisting of fine double-looped or v-shaped ridges.

*Teeth*: pseudocardinal teeth thin, triangular, 2 teeth in left valve, nearly parallel to the hinge line, may be slightly divergent or appear as a single tooth, anterior tooth larger than posterior, and 1 tooth in right valve, occasionally with a thin accessory denticle anteriorly. Lateral teeth relatively long, thin, nearly straight to slightly curved, 2 in left valve, 1 in right valve.

*Interdentum:* moderately long, narrow to nearly absent.

*Lampsilis bracteata – top image, female, Llano River (Colorado River drainage), length 41.0 mm; bottom image, male, Llano River (Colorado River drainage), length 42.0 mm (Mussels of Texas 2020)*

*Nacre*: white or bluish-white, may have a salmon or orange tint; iridescent posteriorly.

*Other*: sexually dimorphic, posterior margin broadly rounded to truncate in females, narrowly rounded to pointed in males; females tend to be more inflated posteriorly than males. Soft tissues white to off-white.

### Habitat
From Mussels of Texas (2020): Occurs in small streams to medium-sized rivers, may penetrate into headwaters. Reported to occur in slow to moderate current in sand, mud, and gravel substrates among large cobble, boulders, bedrock ledges, horizontal cracks in bedrock slabs, and macrophyte beds. Has also been observed inhabiting the roots of cypress trees and vegetation along steep banks. Past authorities have reported this species intolerant of reservoir conditions, but recent surveys suggest it may occasionally persist in some impoundment conditions (Sullivan and Littrell 2020); however, population performance of these populations remains unknown. This species may be intolerant to poor water quality and low flows. Khan et al. (2019) through laboratory thermal tolerance testing showed that 50% mortality,



Texas fatmucket
Lampsilis bracteata

### Habitat cont.
during a 24-h period, of glochidia of L. bracteata occurred at 33.8 ± 0.2°C [LT50 ± 95% CI] (Cherokee Creek), 32.4 ± 0.3°C (Llano River), 34.7 ± 0.3°C (San Saba River), which the authors argued is close to temperatures wild populations may already be experiencing. Khan et al. (unpublished data) testing emersion tolerance showed that 50% mortality of adults of L. bracteata from the Llano occurred at 2.46 days (95% CI: 1.97 – 5.98) at 25°C, which suggests this species may not be able to cope with declining flows.

### Distribution
Endemic to tributaries of the Colorado River drainage in central Texas.

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted

**Surveys cont.**

by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

**Threats cited by USFWS (2021)**

- Increased fine sediment
- Changes in water quality
- Altered hydrology in the form of inundation
- Altered hydrology in the form of loss of flow and scour of substrate
- Predation and collection
- Barriers to fish movement
- Climate change

**Potential mitigation/translocation/propagation actions**

Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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## Texas fatmucket
*Lampsilis bracteata*


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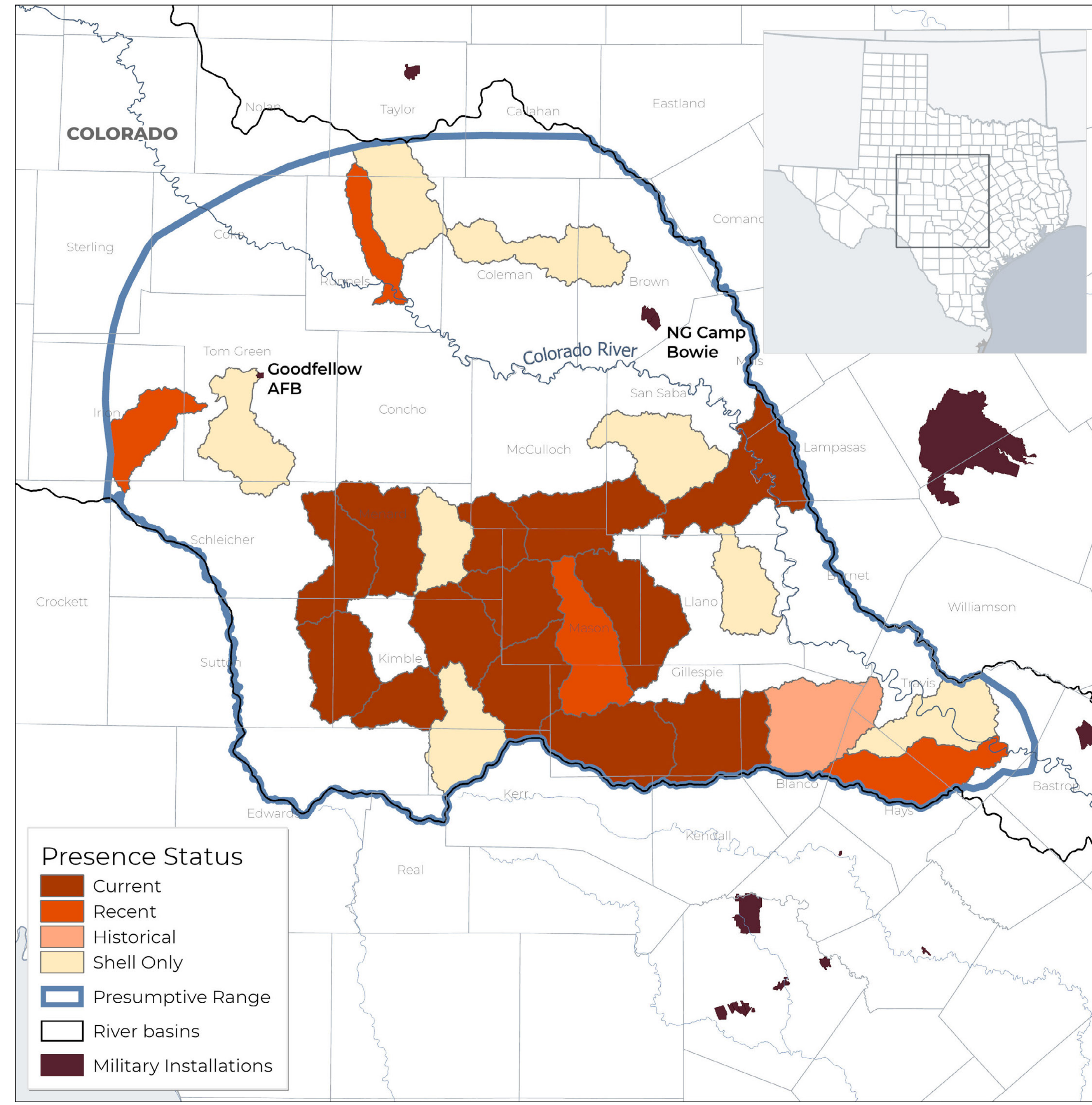
## Texas fatmucket
*Lampsilis bracteata*

## Texas fawnsfoot

*Truncilla macrodon*

### ESA Status

Proposed threatened 26 August 2021.

### Identification

From Mussels of Texas (2020):

*Shell structure:* thin to moderately thick and compressed; outline elliptical to suboval; posterior ridge sharp to rounded.

*Shell color*: yellow-brown, green-brown, yellow or brown with solid rays or broken rays consisting of blotches or patterns of chevron-like markings; surface often glossy to subglossy.

*Shell texture*: without sculpture.

*Beaks*: shallow and slightly above hinge line.

*Beak sculpture*: may have 3–6 faint ridges.

*Teeth*: pseudocardinal teeth compressed, roughened, and triangular shaped; lateral teeth moderately long, thin, straight to slightly curved.

*Nacre*: white to bluish-white, iridescent posteriorly.

*Other*: weakly sexually dimorphic, females broadly rounded to slightly truncate posteriorly whereas males are typically more pointed centrally.

### Habitat

From Mussels of Texas (2020): Occurs in large rivers but may also be found in medium-sized streams. Is found in protected near shore areas such as banks and backwaters but also riffles and point bar habitats with low to moderate water velocities. Typically occurs in substrates of mud, sandy mud, gravel and cobble. Considered intolerant of reservoirs (Randklev et al. 2010; Randklev et al. 2014; Randklev et al. 2017).


*Truncilla macrodon – lower Colorado River (Colorado River drainage), length 44.0 mm (Mussels of Texas 2020)*

### Distribution

Endemic to the Brazos, Colorado, and Trinity river drainages in Texas.

### Management

- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.





### Surveys

Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

### Threats cited by USFWS (2021)

- Increased fine sediment
- Changes in water quality
- Altered hydrology in the form of inundation
- Altered hydrology in the form of loss of flow and scour of substrate
- Predation and collection
- Barriers to fish movement
- Climate change

### Potential mitigation/translocation/propagation actions

Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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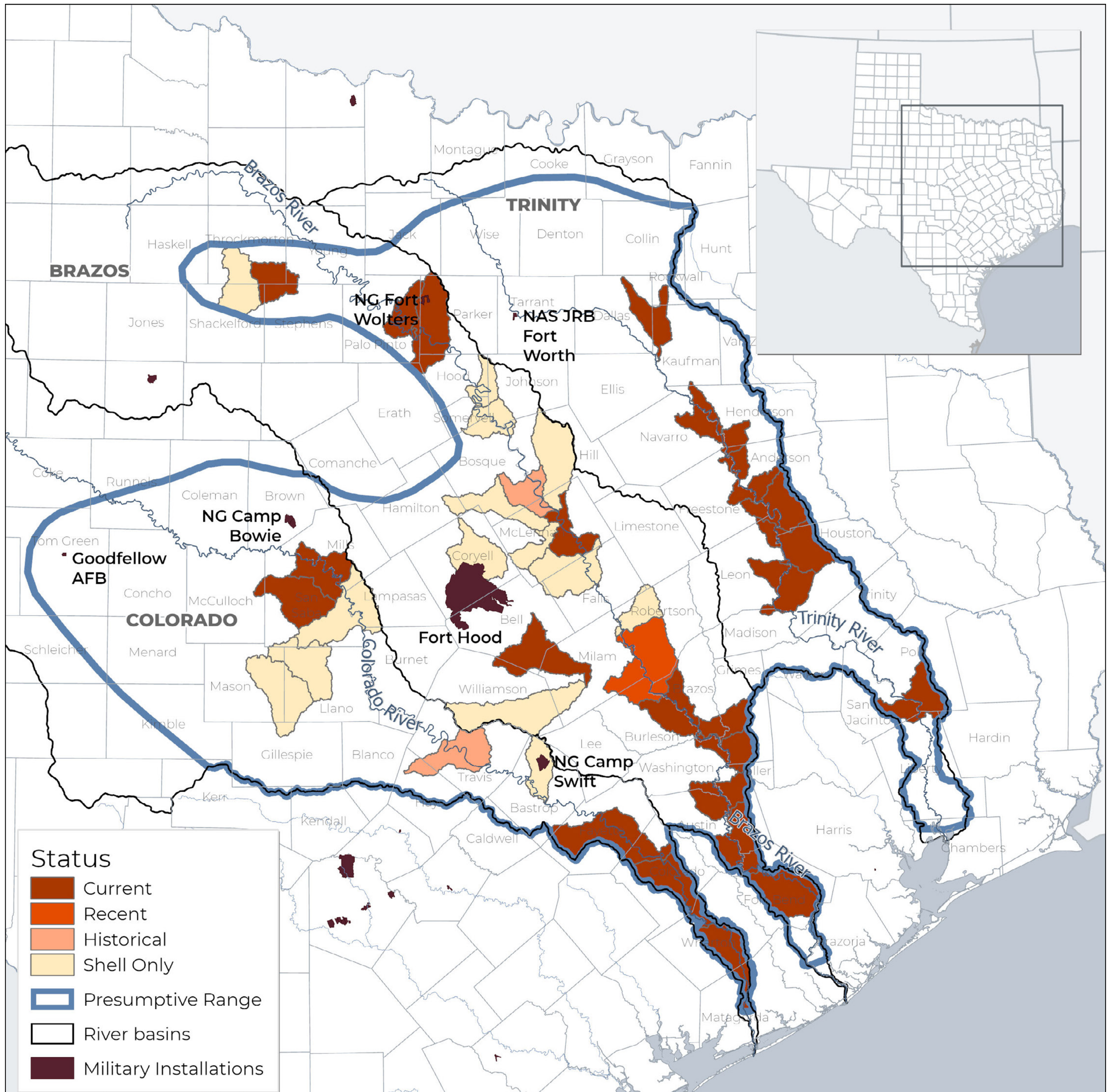
U.S. Fish and Wildlife Service. 2021. Endangered and threatened wildlife and plants; endangered species status with critical habitat for Guadalupe fatmucket, Texas fatmucket, Guadalupe orb, Texas pimpleback, and false spike, and threatened species status with Section 4(d) rule and critical habitat for Texas fawnsfoot. Federal Register 86:47916–48011. https://www.federalregister.gov/documents/2021/08/26/2021-18012/endangered-and-threatened-wildlife-and-plants-endangered-species-status-with-critical-habitat-for

## Texas fawnsfoot

*Truncilla macrodon*




## Texas heelsplitter

*Potamilus amphichaenus*

### ESA Status

Under review, on current 5-year workplan for FY20 but a decision has not been published yet. In 2009, USFWS found that listing the species may be warranted.

### Identification

From Mussels of Texas (2020):
*Shell structure:* thin, brittle, and subinflated; outline elliptical to oblong oval, may have a small, conspicuous, dorsal wing, which can be missing due to erosion or breakage; posterior ridge full and rounded; posterior slope flat to slightly concave, merging with dorsal wing when present.

*Shell color*: dark brown to black and lighter on the beaks, occasionally presents faint green or black rays; surface glossy.

*Shell texture*: smooth except for growth-rest lines.

*Beaks*: low, moderately broad, elevated slightly above the hinge line; umbo cavity shallow.

*Beak sculpture*: absent, indistinct, or faint ridges.

*Teeth*: pseudocardinal teeth triangular, thin, compressed, and sharp, 1 in the left valve, occasionally with a second, reduced, posterior tooth and accessory denticle, 1 tooth in the right valve, rarely with an accessory denticle. Lateral teeth relatively short, thin, straight to slightly curved, 2 in left valve, 1 in right valve.

*Potamilus amphichaenus – Neches River (Neches River drainage), length 124.0 mm (Mussels of Texas 2020)*

*Interdentum*: moderately long and narrow to almost absent.

*Nacre*: white, bluish-white or purple; somewhat clouded to iridescent throughout.

*Other*: weakly sexually dimorphic and often difficult to separate, females inflated at the posterior base and have a more rounded posterior margin than males; soft tissues off-white to tan; apertures are elongate (as much as 1 to 2 inches in length) and can apparently extend through the substrate allowing the mussel to be deeply buried.

### Habitat

From Mussels of Texas (2020): Reported from medium-sized streams to large rivers. Present in some reservoirs (Mauldin 1972; Neck 1986; Neck 1990; Bosman et al. 2015), although the long-term viability of those populations is unknown. In riverine habitats, it is often found in nearshore habitats such banks and backwater pools. Occurs in standing to slow-flowing water, in soft substrates such as mud, silt or sand (Neck and Howells 1994). May tolerate some level of disturbance as it can occur in areas with increased potential for bed mobility. However, its apparent absence downstream of large dams, particularly those that generate hydropower (Randklev et al. 2016), and major urban areas (e.g., Dallas-Fort Worth; Randklev et al. 2017) suggests this species may not be as adaptable as other *Leptodea* or *Potamilus* species. Walters and Ford (2013) noted this species may be susceptible to predation during periods of low

## Texas heelsplitter
*Potamilus amphichaenus*

### Habitat cont.
water due its thin-shelled morphology. Howells et al. (2000) reported high mortality for individuals stranded following dewatering of B.A. Steinhagen Reservoir, Neches River drainage.

### Distribution
Gulf Coast drainages of eastern Texas and western Louisiana. The map below displays its distribution in Texas, which includes the Trinity, Neches, and Sabine river drainages.

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address



## Texas heelsplitter
*Potamilus amphichaenus*

### Surveys cont.
detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

### Threats cited by USFWS (2009)
- Fluctuating water levels from drawdowns

### Potential mitigation/translocation/propagation actions
Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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## Texas heelsplitter
*Potamilus amphichaenus*


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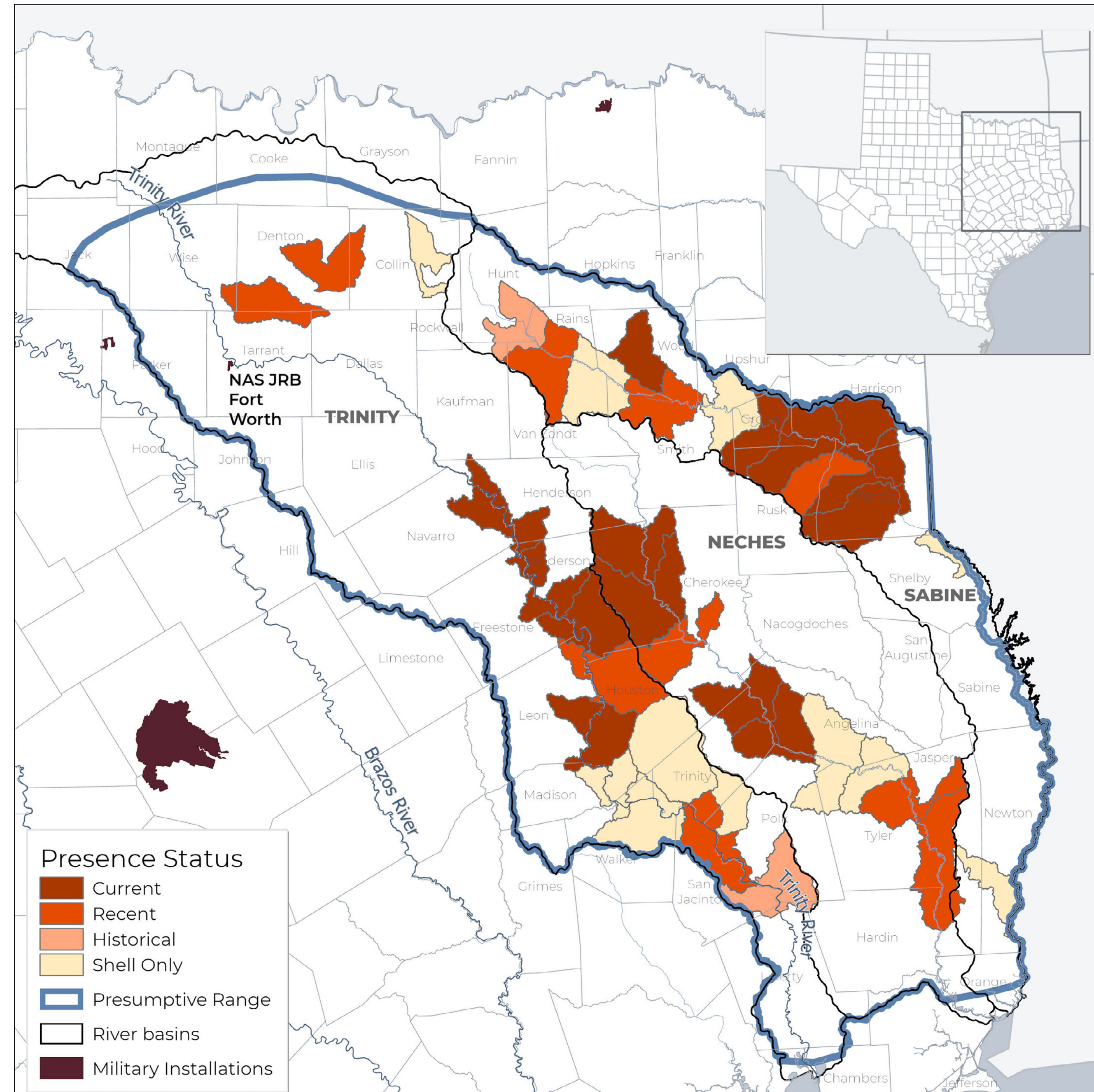
## Texas heelsplitter
*Potamilus amphichaenus*

## Texas pimpleback
*Cyclonaias petrina*

### ESA Status
Proposed endangered 26 August 2021.

### Identification
From Mussels of Texas (2020):
*Shell structure:* moderately to very thick and slightly to relatively inflated; outline subquadrate, subrhomboidal to oval in shape; posterior ridge rounded sometimes biangulate; posterior slope flat to slightly concave, may have angular crenulations. Individuals inhabiting riffles or the upper part of watersheds can produce elongated, compressed morphotypes.

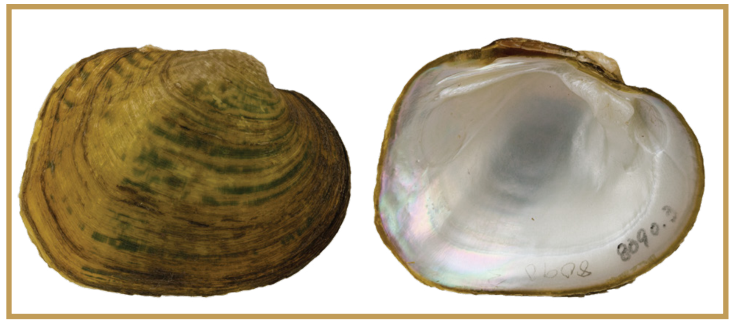
*Shell color*: yellow-green, brown-green, yellow, brown, or black; may have green blotches that resemble irregular rays; surface may be dull to subglossy.

*Shell texture*: without sculpture.

*Beaks*: narrow to broad and moderately high above the hinge line; umbo cavity deep.

*Beak sculpture*: rows of ridges, which often form a distinct cross-hatching pattern.

*Teeth*: pseudocardinal teeth large, triangular, rough, divergent, 2 in the left typically with the posterior tooth being smaller than the anterior, 1 tooth in the right valve, may have accessory denticles anteriorly and/or posteriorly; lateral teeth short to moderately long, thick, straight to slightly curved, 2 in left valve, 1 in right valve.



*Cyclonaias petrina – Llano River (Colorado River drainage), length 46.0 mm (Mussels of Texas 2020)*

*Interdentum*: short, wide, and thick.

*Nacre*: white to bluish-white, iridescent posteriorly.

*Other*: not sexually dimorphic; soft tissues white to off-white.

### Habitat
From Mussels of Texas (2020): Reported from medium-size streams to large rivers primarily in riffles and runs, occasionally occurs in pools. Often found in substrates composed of sand, gravel, and cobble, including mud-silt or gravel-filled cracks in bedrock slabs. Considered intolerant of reservoirs.

### Distribution
Endemic to the Colorado River drainage and adjacent tributaries in Texas.

### Management
- Conduct presence/absence surveys to delineate current distribution on given installation.
- Use standardized sampling methods and reporting procedures in order to compare data collected by different entities and to assess trends in mussel occupancy and population persistence over time and space.
- Conduct qualitative and quantitative sampling to estimate abundance, evaluate size structure and demography, and identify mussel-habitat associations.

## Texas pimpleback
*Cyclonaias petrina*

### Management cont.
- Identify suitable long-term monitoring sites to establish monitoring program and gather baseline information on mussel population performance and persistence.
- Determine annual survivorship, recruitment, and rate of population growth and project population persistence over time.
- Monitor water quality and attempt to eliminate/mitigate potential threats.

### Surveys
Coducting surveys to determine whether mussels occur within an area is an important component of mussel conservation and management. Good sampling designs should have well-articulated objectives, use standardized methods, and account for incomplete detection. Generally, well-articulated sampling designs should address three basic questions: 1) why survey; 2) what to survey; and 3) how to survey. Detectability refers to the probability that a species will be found if it is present and is influenced by observer effects, a species' life history, and environmental conditions, among others. Standardization refers to using the same or similar sampling methods, which is important for reducing heterogeneity in detectability and for permitting comparisons of results between studies conducted by different researchers. Sampling programs should clearly define and state their goals, variables of interest (e.g., species richness), and methods that are chosen, which should address detection error. If this is not done, then these programs run the risk of providing data that at best is biased and at worst leads to inappropriate management decisions.

For mussels, a monitoring program is initially focused on determining whether they are present at a site using qualitative techniques followed up by quantitative techniques to further describe the population in more detail. Details on both approaches (i.e., qualitative and quantitative) can be found in reviews provided by Dunn and Strayer (2010), Metcalfe-Smith et al. (2000), Strayer and Smith (2003), and Obermeyer (1998).

### Threats cited by USFWS (2021)
- Increased fine sediment
- Changes in water quality
- Altered hydrology in the form of inundation
- Altered hydrology in the form of loss of flow and scour of substrate
- Predation and collection
- Barriers to fish movement
- Climate change

# Texas pimpleback
*Cyclonaias petrina*

## Potential mitigation/translocation/propagation actions
Translocation is an option if no other solutions exist. For translocation to be successful, mussels must be handled correctly during the translocation process and must be translocated to suitable habitat. Genetic and ecological risks should also be considered before a relocation site is selected. Translocated mussels should be monitored yearly for a period of two years. See TPWD's Freshwater Mussel Survey and Relocation Protocols, Hart et al. (2016), and Tsakiris et al. (2017) for more information.

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# Texas pimpleback
*Cyclonaias petrina*

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## Texas pimpleback

*Cyclonaias petrina*

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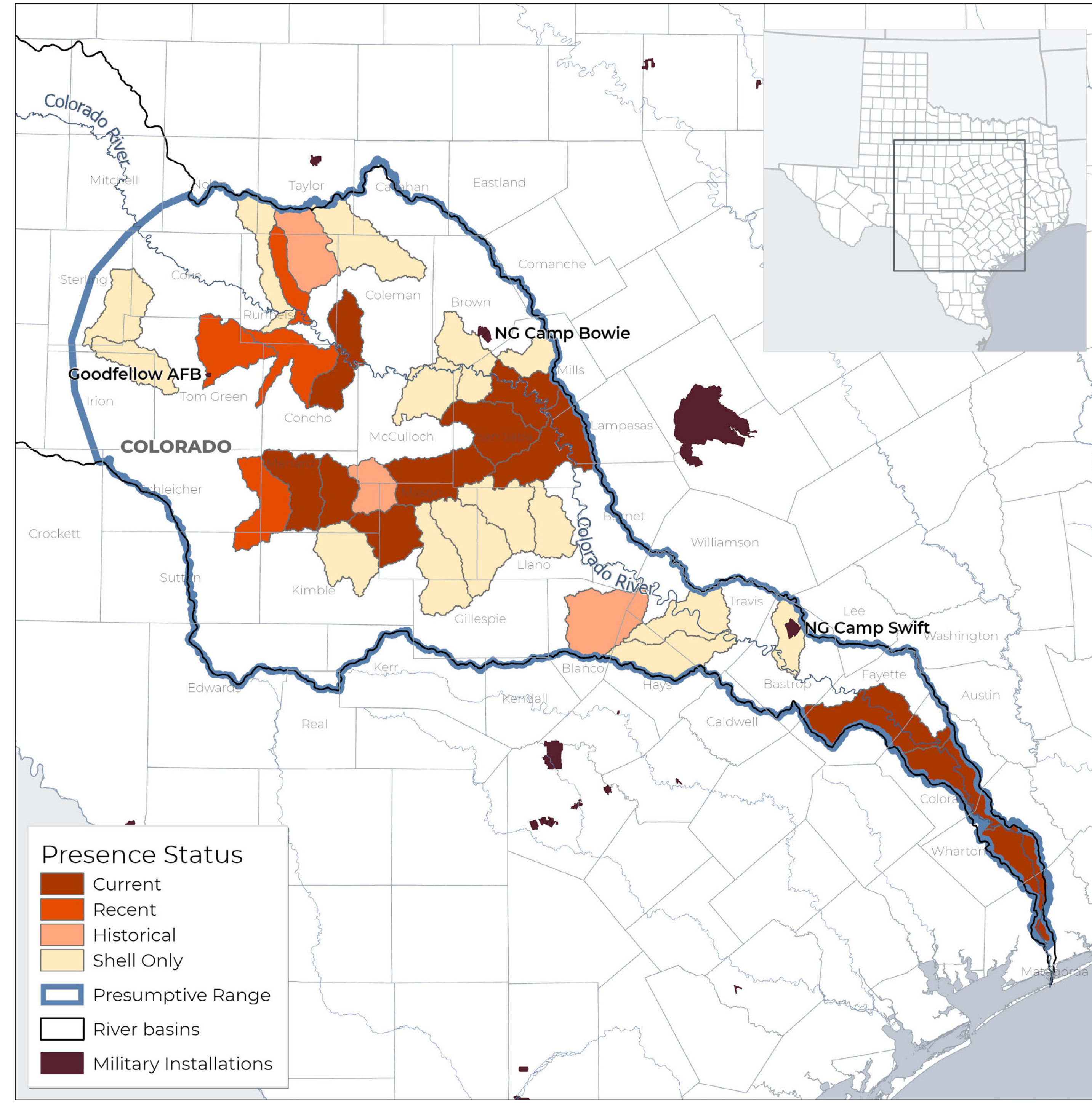
## Texas pimpleback

*Cyclonaias petrina*



# Plants

**big red sage**
**bracted twistflower**
**Correll's false dragonhead**



## big red sage

*Salvia penstemonoides*

*Salvia penstemonoides* (Lee Page; https://www.wildflower.org/gallery/result.php?id_image=31951)

*Salvia penstemonoides* (Wynn Anderson; https://www.wildflower.org/gallery/result.php?id_image=68703)

### ESA Status

Under review, on current 5-year workplan for FY23. In 2009, USFWS found that listing the species may be warranted.

### Identification

Adults 54–110 mm (3.1–4.3 A large, mostly glabrous, perennial species with branching, square stems up to 1.5 m (5 ft.) tall. Leaves are opposite, on petioles in lower leaves, sessile in upper leaves. Leaf shape is linear to oblong-lanceolate with margins entire to finely dentate, ciliate. Flowers are red to reddish purple, corolla is two-lipped with the upper lip extending beyond the lower lip, the lower lip two-lobed. Flowers occur in clusters on terminal racemes characteristic of other Salvia species. Fruit is a set of 4 small nutlets (Poole et al. 2007; Eason 2018).

### Phenology

Perennial species, leaves are conspicuous for most of the year especially basal leaves. Flowering occurs from June to October (Poole et al. 2007; Eason 2018).

### Similar species

Two other red-flowered sage species occur within its range including cedar sage (*S. roemeriana*) and blood sage (*S. coccinea*), both of which are half the size of big red sage. Another species, cardinalflower (*Lobelia cardinalis*), looks superficially similar because of its large size and red colored flowers but has alternate leaves and different flower morphology with three lower petals and two upper petals all united at the base (Poole et. al. 2007).

### Habitat

From TPWD's Rare, Threatened, and Endangered Species of Texas database (2021): Moist to seasonally wet, steep limestone outcrops on seeps within canyons or along creek banks; occasionally on clayey to silty soils of creek banks and terraces, in partial shade to full sun.

## big red sage

*Salvia penstemonoides*

### Distribution

Endemic to the Edwards Plateau of Central Texas, it was thought extinct until it was rediscovered in the 1980s by Marshal Enquist. There are currently six small known populations in the wild in Bandera, Kendall, Kerr, and Real counites. Historical distribution also included Bexar, Gillespie, Guadalupe, Uvalde, and Wilson counties. Since its rediscovery it has become widely available in the plant nursery trade in Texas (Poole et al. 2007).

### Management

Threats to this species have not been extensively studied. Protection of known wild populations will likely depend upon preventing or mitigating disturbances caused by herbicide use, grazing, collection, erosion, flooding, and the lowering of ground or surface water levels wherever it is found (Center for Plant Conservation [CPC] 2020). We are aware of no studies of in-situ conservation which have been conducted to determine the efficacy of conservation or management strategies in wild populations.

Cultivation of this species has been very successful, and it is now widely available within the nursery trade. However, nursery stock is assumed to have relatively low genetic diversity and may be maladapted to conditions across its range which would pose a risk to wild populations. While nursery stock of this species is available, protection of existing wild populations in their habitat is key to preserving the genetic diversity and local adaptations of the species.

### Surveys

In general, presence/absence surveys are recommended to occur during blooming periods (June–October) to increase visibility and ease of identification. Surveys should concentrate on achieving greatest coverage of seasonally moist or wet areas, especially creek beds, riverbanks, limestone seeps, and other riparian areas. Systematic belt transects and meander surveys are commonly used techniques for a semiquantitative procedure in rare plant presence/absence surveys.

Surveyors should be trained in plant identification and be familiar with similar species that occur in the area. It is recommended that at least one member of the team view the species in its native habitat before conducting surveys. At a minimum, herbarium collections should be studied beforehand, and images be made available to the survey crews for reference. If the target species is found, GPS locations should be marked, density estimated, phenology and microhabitat described, dominant



## big red sage

*Salvia penstemonoides*

### Surveys cont.

associated species identified, and photos taken at a minimum. Adverse conditions in any given year such as recent flooding, drought, disease, predation, or other recent disturbances can preclude identification. Areas identified as potential habitat should be resurveyed multiple years to ensure that plants are not missed (Given 1994; USFWS 2000).

Monitoring of known populations should be conducted regularly to establish population trends, document effects of current management and land use, track habitat quality or threats, and to generate data to better understand individual species management requirements (Elzinga et al. 1998). If identified on an installation, regular monitoring should be considered a key component to any future management program. As part of their monitoring of rare and endangered plant species surveys along highway rights-of-way, Poole and Janssen (1996) monitored big red sage population demography by conducting total counts of individuals, and plant vigor by recording the number of primary and secondary stems as well as the number of flowers/fruits per individual plant.

### Threats cited by USFWS (2009)

- Aquifer drawdown
- Commercial uses
- Flooding

### Threats cited by CPC (2020)

- Herbicides
- Erosion
- Lowering of the water table

### Potential mitigation/translocation/propagation actions

Introductions using nursery stock should be discouraged and translocations of wild plants should always be considered a strategy of last resort for mitigation. There may however exist opportunities to expand the range of the species or to increase population sizes for mitigation purposes through propagation and outplanting of wild plants if "no net loss" is achieved. The CPC has created a simple assessment tool to determine situations in which a reintroduction may be warranted and guidelines on how to implement reintroductions (CPC 2019).

A living collection is maintained at the San Antonio Botanical Garden where it has been reported that the species is grown easily from seed and is easily propagated

**Potential mitigation/translocation/propagation actions cont.**

from cuttings or root division (CPC 2020). No seed collection has yet been sent to the National Center for Genetic Resources Preservation, but seed collections are held elsewhere (CPC 2020). Additionally, while it has become a common landscaping species, we found no record of reintroduction trials having been attempted.

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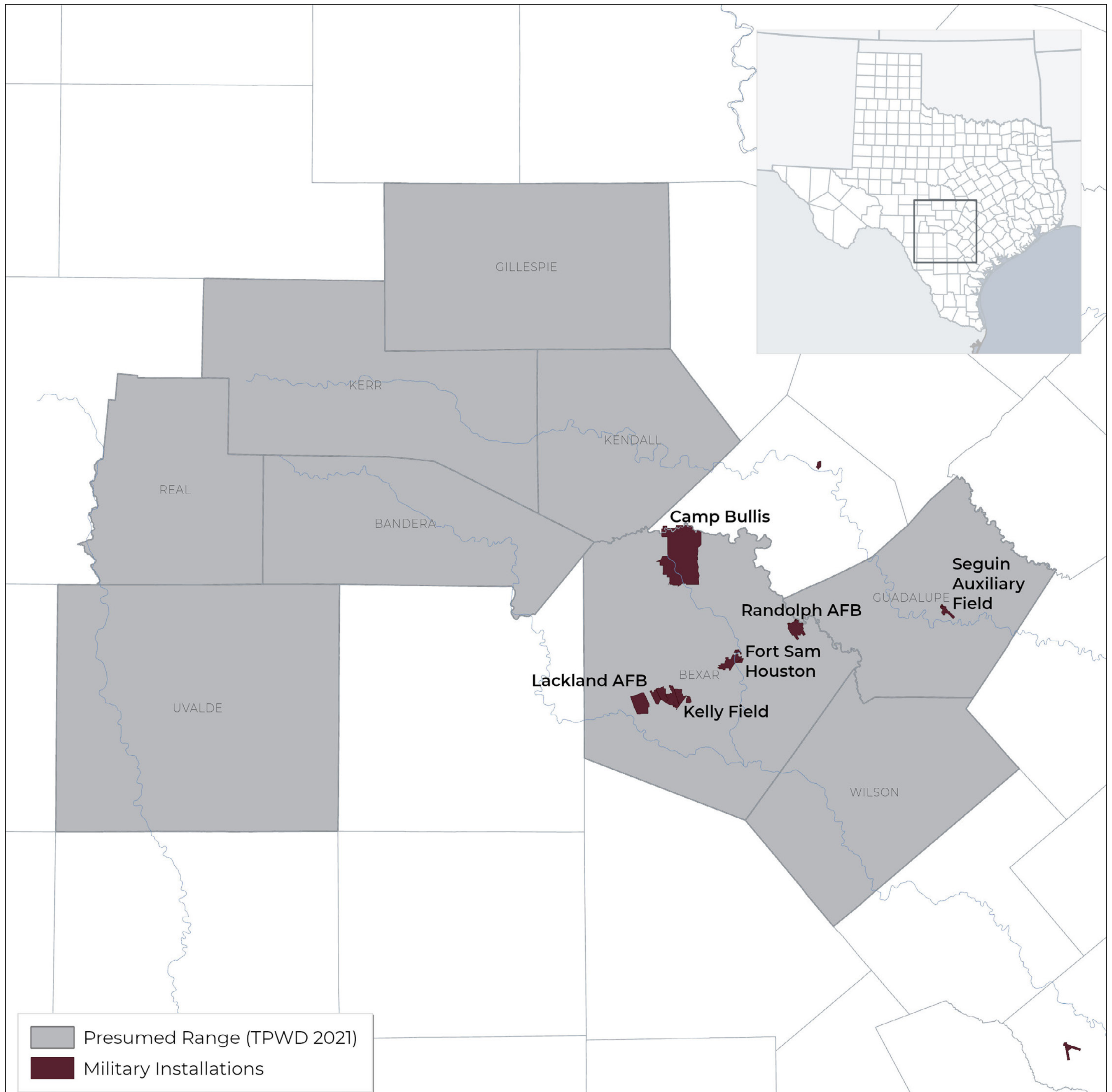
## big red sage

*Salvia penstemonoides*




## bracted twistflower

*Streptanthus bracteatus*

### ESA Status

Proposed threatened 10 November 2021.

### Identification

An annual herbaceous species with simple or branched erect glabrous stems. Leaves are alternate, basal leaves form a rosette, are petiolate, irregularly, and broadly lobed or dentate; middle to upper cauline leaves are simple, oblong to ovate, clasping stem. Flowers are showy lavender-purple, 4 petals, 4 sepals, occurring in bracted terminal racemes, lower bracts leaf-like, upper bracts reduced. Fruit is a subsessile, flattened, linear silique, seeds are flattened oblong and broadly winged (Poole et al. 2007; USFWS 2021). Positive identification of this species is very difficult prior to flowering and can be easily confused with rosette-forming sunflowers (Asteraceae) or other mustard (Brassicaceae) species (Strong and Williamson 2015; USFWS 2021).

### Phenology

A winter annual, seeds germinate in response to fall and winter rainfall, forming basal rosettes which have been observed from October through March. Flower stalks emerge in spring from mid-April to late May or early June. Fruits mature, dry, and split to release seed in early summer and have primarily been collected in June, occasionally as late as August. As fruits mature the plant begins to die back especially as temperatures rise during the summer. Population densities and locations within their immediate habitat can fluctuate widely from year to year and may be driven by annual winter precipitation (Poole et al. 2007; Strong and Williamson 2015; USFWS 2021).

*Streptanthus bracteatus (W.D. and Dolphia Bransford; https://www.wildflower.org/gallery/result.php?id_image=6732)*

### Similar species

When only the basal rosette is present or when fruiting, it is easily confused with Brazos rockcress (*Streptanthus petiolaris*) but can be distinguished by the absence of bracts at the base of the flower's stem as well as longer, rounder fruit (Strong and Williamson 2015).

Its range overlaps with that of broadpod jewelflower (*S. platycarpus*) in its western and southern range. Poole et al. (2007) noted that bracted twistflower flowering pedicels are subtended by a small but conspicuous bract whereas in broadpod jewelflower, the bracts

## bracted twistflower

*Streptanthus bracteatus*

### Similar species cont.

are present below only the lowermost pedicel. Additionally, stamens of bracted twistflower are tetradynamous (having 4 long and 2 short stamens), while broadpod jewelflower has 2 long, 2 medium, and 2 short stamens (USFWS 2021).

### Habitat

Found on steep to moderate slopes and canyon bottoms over shallow, well-drained gravelly clays and clay loams over limestone. Several known associated soils include Tarrant, Brackett, or Speck over Edwards, Glen Rose, and Walnut geologic formations (Poole et al. 2007). Analysis of soil samples from 5 Travis County sites showed soils were 36–46% sand, 18–32% clay, 4.2–5.2% organic matter and 7.7–8.1 pH (Zippin 1997). It has been suggested that limestone seeps occurring in conjunction with humus deposition may be important to bracted twistflower distribution (Strong and Williamson 2015).

While often found in dense shrub growth in oak juniper woodlands, high canopy cover and shaded areas are likely not ideal for this species (Leonard 2010; Fowler et al. 2012; Leonard and Van Auken 2013; Fowler 2014). Its persistence in dense thickets is attributed to the protection it provides from herbivory, especially from white-tailed deer (Odocoileus virginianus) (Strong and Williamson 2015). Fowler (2010) found that plant performance increased with less than 50% canopy cover if also protected from herbivory and Leonard (2010) found a significant increase in total biomass with increasing light levels.

### Distribution

Endemic to the Texas Hill Country.

### Management

Herbivory from deer especially white-tailed deer is a major threat. Populations can be protected through a combination of exclusion (i.e., fencing and caging), and deer herd management (i.e., hunting). While high deer densities in the Edwards Plateau make deer management a high priority, herbivory from squirrels and rodents has also been observed and has caused the failure of at least one reintroduction attempt. Additional herbivory from insect species and other ungulates pose a threat as well.

Light availability is also a crucial management concern. While this species likely requires some degree of shading, woody canopy cover should be maintained or



## bracted twistflower

*Streptanthus bracteatus*

### Management cont.

reduced to less than 50% if that does not increase chances of herbivory (Fowler 2010). There is some evidence that this species is fire adapted so prescribed fire should be evaluated as a management tool (Fowler 2010). Trampling and erosion caused by hiking, biking, or other similar disturbances in or near known populations should be prevented, mitigated, or reduced (Fowler 2010). This species is susceptible to infection from an unknown parasitic fungus and should be protected against infection in any reintroduction attempts (Fowler 2010). As with all plant species of concern, mowing and herbicide use near known populations should be carefully monitored to ensure they will not cause unintended population extirpation.

### Surveys

Identification of this species is challenging so surveys should be conducted during its blooming period (mid-April to May) by a trained survey crew. Given the difficulty of identification it is recommended that the survey crew have at least one member trained in plant identification and who has observed the species in the wild during the blooming period. Additionally, the timing of blooming can fluctuate from year to year so nearby populations should be monitored prior to conducting surveys to determine when the species is in bloom. All surveyors should be familiar with similar species that occur in the area. Herbarium collections/photographs should be studied beforehand by all survey crew and images be made available for reference. Systematic belt transects and meander surveys are commonly used techniques for a semiquantitative procedure in presence/absence rare plant surveys. Adverse conditions in any given year such as recent flooding, drought, disease, predation, or other recent disturbances can preclude identification. Areas identified as potential habitat should be resurveyed multiple years to ensure that plants are not missed (Given 1994; USFWS 2000). For example, one population of this species was found after three previous surveys in that location had failed to find any plants (Carr 2001).

Monitoring of known populations should be conducted regularly to establish population trends, document effects of current management and land use, track habitat quality or threats, and to generate data to better understand individual species management requirements (Elzinga et al. 1998). If identified on an installation, regular monitoring should be considered a key component to any future management program. If the target species is found, GPS locations should be marked, density estimated or simple counts made, phenology and microhabitat

### Surveys cont.

described, dominant associated species identified, and photos taken at a minimum. The locations of sub-populations are somewhat fluid and can change from year to year so surveys should expect locations to shift and not concentrate within too restrictive of an area (Strong and Williamson 2015). To account for this, Fowler (2014) suggested that unoccupied areas <50 m (164 ft.) from known populations be considered potential habitat. Strong and Williamson (2015) recommended surveys be conducted along multiple line transects with 30 1-$m^2$ randomly chosen but regularly placed quadrats. Canopy coverage of associated species should be monitored to track light availability. Fowler (2010) recommended canopy measurements be taken with a spherical crown densiometer read at a height of 1 m. Additional individual plant vigor characteristics such as rosette diameter, number of rosette leaves, date of first flowering stalk, number of buds, and height of flowering stalk can be used to evaluate plant performance (Zippin 1997; Fowler 2010; Strong and Williamson 2015). Fowler (2010) suggested that length of flowering pods is one of the best non-destructive measures of reproductive success.

### Threats cited by USFWS (2021)

- Land use changes
- Changes in the structure and composition of vegetation and in wildfire frequency
- Herbivory
- Recreational use of habitats
- Pathogens
- Demographic consequences of small population sizes
- Genetic consequences of small population sizes

### Potential mitigation/translocation/propagation actions

This species has been successfully grown from seed but only one out of eight reintroduction attempts has been successful long-term (Strong and Williamson 2015). Fowler (2010) germinated seeds in a greenhouse using Metro Mix 702 potting soil and watered once or twice per day with a weak solution of a complete fertilizer. All plants were sprayed with a sulfur garden fungicide concentrate and neem oil to prevent powdery mildew, and a soil drench of *Bacillus thuringiensis israelensis* was used to control fungal gnats. Plants were hardened off outside and then transplanted out to areas identified as good habitat. A dripline irrigation system was installed to help establishment. Reintroduction was only successful when plants were caged and protected from herbivory (Fowler 2010). Every attempt to introduce plants in areas not already previously occupied by the species has been unsuccessful (Strong and Williamson 2015).



bracted twistflower
*Streptanthus bracteatus*

### Potential mitigation/translocation/propagation actions cont.

Genetic analysis has shown substantial differentiation between populations so introduced plants should be sourced from nearby populations to avoid altering local genetic adaptations (Strong and Williamson 2015). The Center for Plant Conservation (CPC) has created a simple assessment tool to determine situations in which a reintroduction may be warranted and guidelines on how to implement reintroductions (CPC 2019). Translocations of existing wild populations are never recommended except as a strategy of very last resort for mitigation.

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## bracted twistflower

*Streptanthus bracteatus*




## Correll's false dragonhead

*Physostegia correllii*

### ESA Status

Under review, not on current 5-year workplan. In 2011, USFWS found that listing the species may be warranted.

### Identification

A rhizomatous perennial species with simple or branched glabrous stems that can grow up to 1.8 m (6 ft.) tall. Rhizomes are thick, elongate, and horizontally creeping giving rise to multiple branching stems. Leaves are leathery and firm, opposite, sessile, with bases tapering, tips pointed, margins serrate to dentate, up to 7 cm (2.75 in.) wide. Flowers are snapdragon-like, occurring on short pedicels that crowd on single or branching terminal spikes. Corolla lavender-pink, spotted or streaked with purple. Bilabiate, with upper lip erect, wavy margin, lower lip 3-lobed with the middle lobe largest, 4 stamens. In Texas, specimens have stalked glands on the calyx. Fruit is a set of 4 smooth, ovoid, angled nutlets. Plants form clumps of clones comprising one or a few individuals (Poole et al. 2007; Eason 2018; Center for Plant Conservation [CPC] 2020).

### Phenology

Perennial species, flowering occurs from May to September.

### Similar species

Numerous other *Physostegia* species occur within its Texas range however Correll's false dragonhead has much broader leaves than most. Poole et. al. (2007) notes

*Physostegia correllii (Larry Allain;* https://plants.usda.gov/home/plantProfile?symbol=PHCO17*)*

that showy false dragonhead (*P. pulchella*) and finger false dragonhead (*P. digitalis*) can also exhibit broad leaves, but both have short vertical rhizomes. Stalked glands are absent or rare in showy false dragonhead and finger false dragonhead, and in finger false dragonhead the flower is white to pale lavender (Poole et. al 2007).

### Habitat

A water-loving species historically associated with wetland habitats of the Gulf Coastal region of Texas and Louisiana (CPC 2020). Remaining populations now occur in less stable riparian areas, stream sides, creek beds, small islands in rivers, as well as man-made drainage features such as irrigation channels and roadside ditches (Poole et al. 2007; CPC 2020). Associated soils are wet, silty clay loams or seepy, mucky, sometimes gravelly soils, underlain by Austin Chalk limestone in some areas. Colonies of Correll's false dragonhead at Lady Bird Lake in Travis County are found growing within light to moderate canopy cover, with absent or sparse

## Correll's false dragonhead

*Physostegia correllii*

### Habitat cont.

undergrowth, on saturated alluvial organic or silty soils parallel to the water's edge or in flat sediment banks (Williams and Manning 2020). Williams and Manning (2020) speculate that Correll's false dragonhead may be a stream edge specialist which thrives on newly deposited sediment banks after flooding and scouring events.

### Distribution

This species ranges from northern Mexico through Texas to Louisiana. In Texas, its historical range included at least seven counties and extant populations are in Galveston, Kinney, Travis, Val Verde, and Zapata counties. A historical record exists from Bexar County and the species is recorded as extirpated from Gillespie County (Poole et. al 2007).

### Management

Additional research is required to properly evaluate the habitat and management requirements of this species (CPC 2020). However, since this species is a riparian wetland specialist, proper management will require protection of water levels and associated riparian areas to maintain its habitat. Along Lady Bird Lake, slow-moving waters allow deposition of fine sediments and organic debris after minor flooding events which may benefit Correll's false dragonhead (Williams and Manning 2020). Protection of this hydrological regime will be key to its continued presence along this waterway. Additionally, control of non-native species, management of canopy cover and undergrowth, prevention of erosion, and prevention or mitigation of man-made disturbances such as mowing, trampling, or herbicide use will likely be key to protection of the species. The extent to which these factors are important for conservation of this species is yet to be determined.

### Surveys

In general, presence/absence surveys are recommended to occur during blooming periods (May–September) to increase visibility and ease of identification. Surveys should concentrate on achieving greatest coverage of stream sides, creek beds, small islands in rivers, as well as man-made drainage features such as irrigation channels and roadside ditches. Systematic belt transects and meander surveys are commonly used techniques for a semiquantitative procedure in rare plant presence/absence surveys.

Surveyors should be trained in plant identification and be familiar with similar species that occur in the area. It is recommended that at least one member of



## Correll's false dragonhead

*Physostegia correllii*

### Survey cont.

the team should view the species in its native habitat before conducting surveys. At a minimum, herbarium collections should be studied beforehand, and images be made available to the survey crews for reference. If the target species is found, GPS locations should be marked, density estimated, phenology and microhabitat described, dominant associated species identified, and photos taken at a minimum. Adverse conditions in any given year such as recent flooding, drought, disease, predation, or other recent disturbances can preclude identification. Areas identified as potential habitat should be resurveyed multiple years to ensure that plants are not missed (Given 1994; USFWS 2000).

Monitoring of known populations should be conducted regularly to establish population trends, document effects of current management and land use, track habitat quality or threats, and to generate data to better understand individual species management requirements (Elzinga et al. 1998). If identified on an installation, regular monitoring should be considered a key component to any future management program. Since Correll's false dragonhead typically can grow along the edge of surface water bodies, kayaks may be able to be used to monitor plants along riverbanks (e.g., Williams and Manning 2020). Williams and Manning (2020) recorded soil type, colony length, colony width, maximum height of colony, stem counts, canopy density, and associated species.

### Threats cited by Williams and Manning (2020)

- Drainage alterations
- Stream bank erosion
- Competition from non-native species
- Disturbances such as mowing, herbicide application, and construction
- Foot traffic

### Potential mitigation/translocation/propagation actions

This species is easily propagated from cuttings or divisions (CPC 2020). Germination of seeds has been accomplished by soaking seeds in 500 pm of gibberellic acid for 24 hours and placing them on distilled water-dampened paper to improve and promote germination. Germination studies revealed 30% success from seeds air dried at room temperature for 6 months and planted in potting soil mix (CPC 2020). Seed is stored at Mercer Arboretum and Botanic Gardens, Lady Bird Johnson Wildflower Center, and the National Center for Genetic Resources Preservation (CPC 2020). Plants are currently maintained in the Mercer Endangered Species Garden.

# Correll's false dragonhead

*Physostegia correllii*

### Potential mitigation/translocation/propagation actions cont.

As part of the restoration of Blunn Creek Delta at Lady Bird Lake in Travis County, Correll's false dragonhead seed was collected and germinated at a nursery. Plants were then reintroduced on-site near existing colonies and the site was managed and monitored for 12 months. Management included treatment of nearby exotic species including elephant ear (*Colocasia* species) (Walther and Wilson 2017). Caging was used to prevent herbivory, and over the 12-month period the introduced plants survived. Correll's false dragonhead is occasionally planted along the Ann and Roy Butler Trail as part of additional beautification projects, but no information is readily available on the long-term success or failure of these projects (Williams and Manning 2020). The CPC has created a simple assessment tool to determine situations in which a reintroduction may be warranted and guidelines on how to implement reintroductions (CPC 2019). Translocations of existing wild populations are never recommended except as a strategy of very last resort for mitigation.

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# Correll's false dragonhead

*Physostegia correllii*


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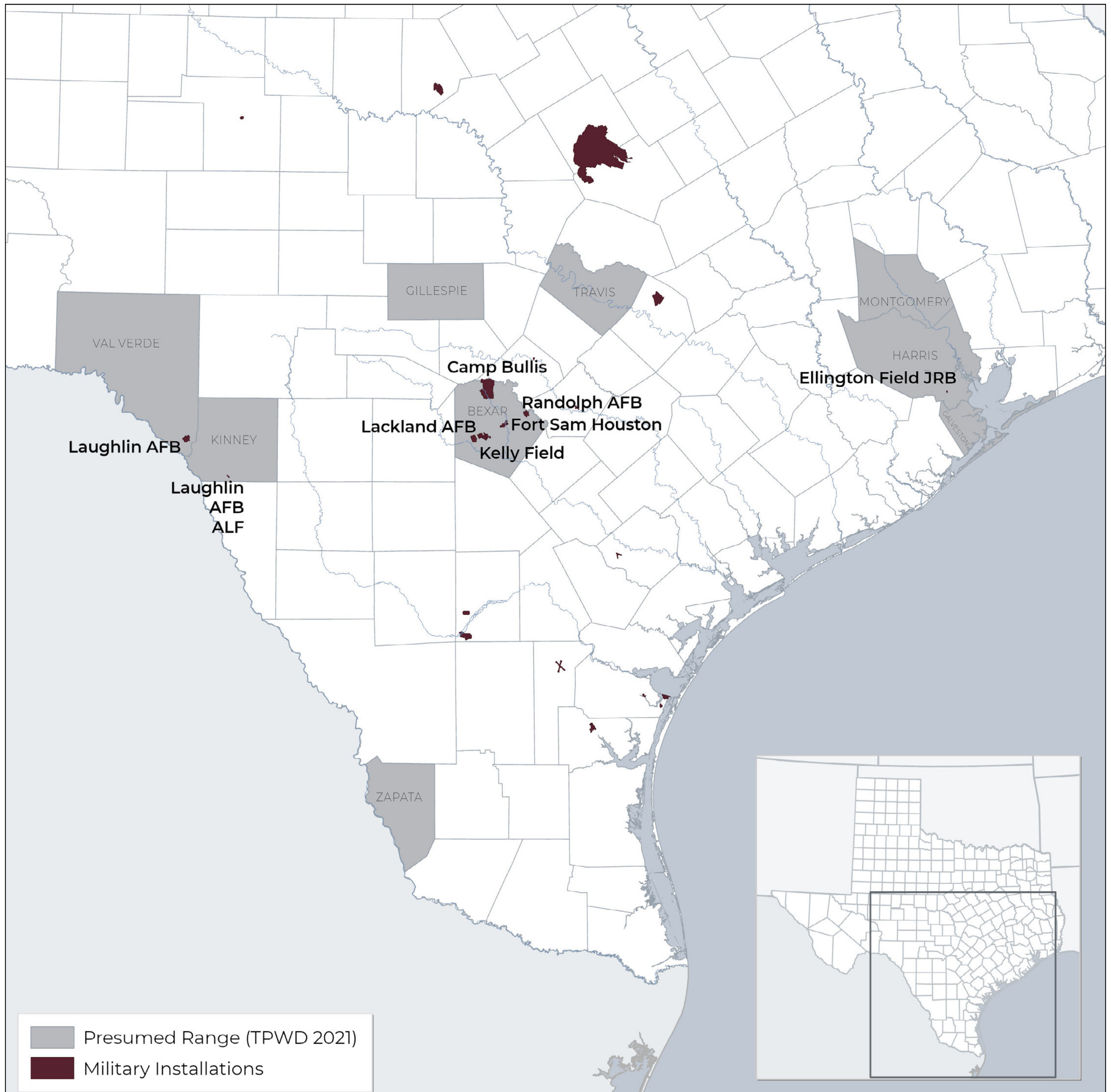
## Correll's false dragonhead

*Physostegia correllii*




# Reptiles

- alligator snapping turtle
- plateau spot-tailed earless lizard
- Tamaulipan spot-tailed earless lizard
- Rio Grande cooter
- western chicken turtle

## alligator snapping turtle
*Macrochelys temminckii*

### ESA Status
Proposed threatened 9 November 2021.

### Identification
Largest species of freshwater turtle in North America; can reach length of 80 cm (31 in.) and weight of 113 kg (249 lb.). Alligator snapping turtles have large heads, long tails, and upper jaws with strongly hooked beaks. The carapace is dark brown with three keels and often has algal growth. The plastron is hingeless, smaller than the carapace, cross-shaped, and grayish brown. The eyes are positioned on the sides of the head and are surrounded by small, fleshy, pointed projections. Numerous epidermal projections are also present on the chin, neck, and sides of the head. The tongue has a wormlike process that is used to lure prey within biting range (Ernst et al. 1994).

### Habitat
From TPWD's Rare, Threatened, and Endangered Species of Texas database (2021): Aquatic: Perennial water bodies; rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near running water; sometimes enters brackish coastal waters. Females emerge to lay eggs close to the waters edge.

### Distribution
Confined to river systems that drain into the Gulf of Mexico. In Texas, found east of (and including) the San Jacinto and Trinity rivers, in the Red River below Lake Texoma, in the Big Cypress Creek and Sulphur River

*Macrochelys temminckii (Toby J. Hibbitts)*

systems, and in bayous that feed into Galveston Bay near Houston (Buffalo Bayou, Armand Bayou). Found in the Trinity River up to Tarrant County, but not known to occur anywhere in the Brazos River or other rivers west of there.

### Management
Alligator snapping turtle populations would likely benefit from actions promoting hatchling and juvenile survival, as small individuals are highly vulnerable to predators. Actions should also be taken to reduce bycatch and poaching.

### Surveys
All studies reviewed used baited hoop nets to survey for alligator snapping turtles. However, environmental DNA (eDNA) surveys are also an option (Feist et al. 2018).

### Threats cited by USFWS (2021)
- Harvest/collection
- Bycatch
- Habitat degradation and loss
- nest predation
- Inadequacy of existing regulatory mechanisms



## alligator snapping turtle
*Macrochelys temminckii*

### Potential mitigation/translocation/propagation actions
Captive rearing, head-starting, and reintroductions are all potential conservation actions for the alligator snapping turtle. See Riedle et al. (2008), Moore et al. (2013), Anthony et al. (2015), Dreslik et al. (2017), and Glorioso et al. (2020) for more information. Currently, Stephen F. Austin State University is conducting a study on confiscated turtles that have been reintroduced in Texas (Fuller 2021).

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## alligator snapping turtle
*Macrochelys temminckii*

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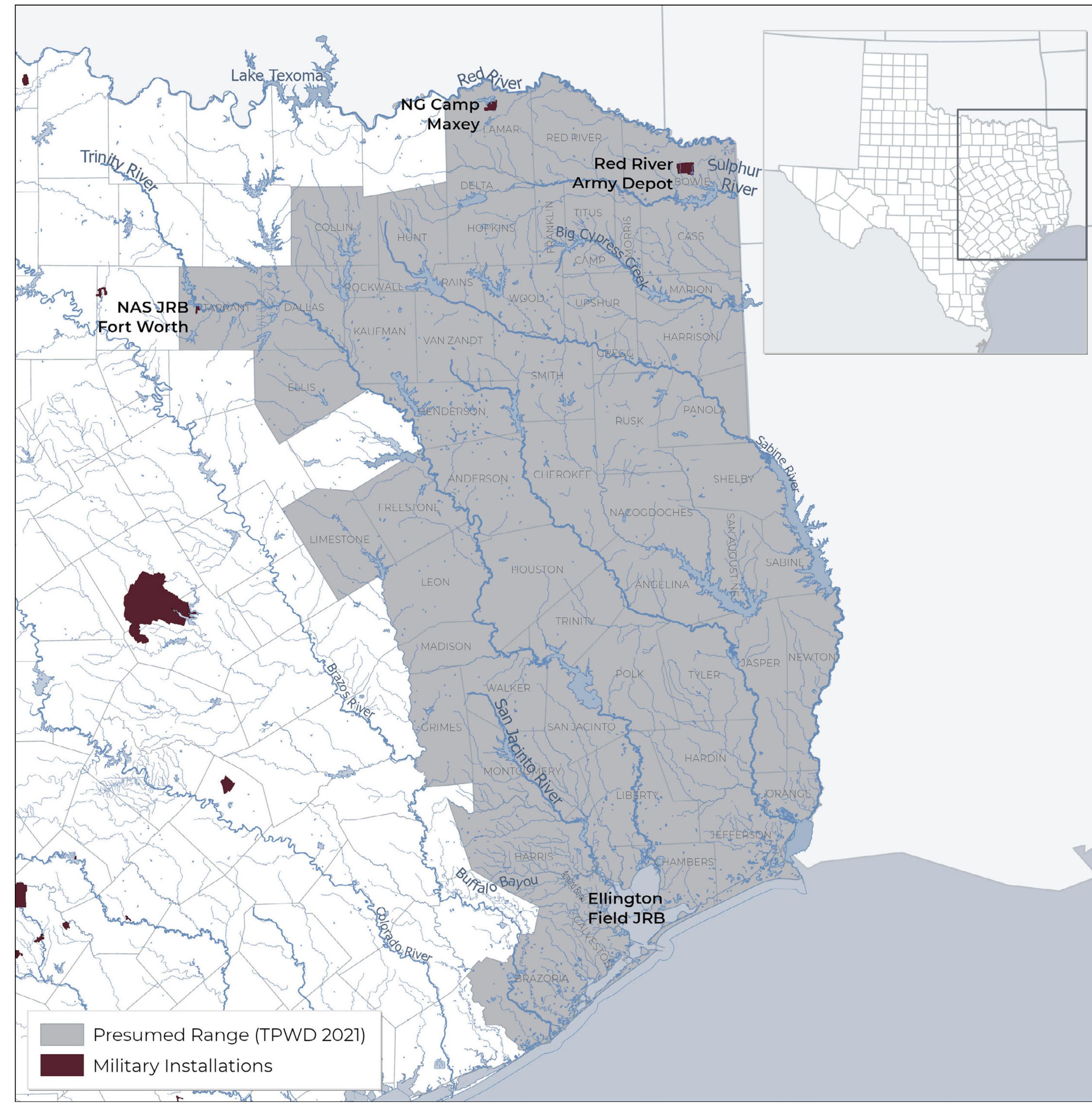
## alligator snapping turtle
*Macrochelys temminckii*

## plateau spot-tailed earless lizard
## Tamaulipan spot-tailed earless lizard
*Holbrookia lacerata* and *subcaudalis*

### ESA Status
Under review, on current 5-year workplan for FY22. In 2011, USFWS found that listing *Holbrookia lacerata* may be warranted, and in 2019, *H. subcaudalis* was described as a distinct species separate from *H. lacerata*.

### Identification
**Plateau spot-tailed earless lizard:** This is a small, earless lizard with an average of 4 (range 0–10) black spots on the underside of the tail. The average snout-vent length (SVL) is 54 mm (2.1 in.; range 32–63 mm [1.3–2.5 in.]), and the paravertebral and dorsolateral body blotches are often fused. An average of 2 (range 0–6) out of an average of 6 (range 4–9) blotches are fused. The blotches form two rows of transverse bands with the dorsal edges of the bands usually narrowing and extending anteriorly. The dark blotches on the hind legs usually form distinct bands with an average of 7 (range 4–11) leg bands and blotches. Some individuals have black lateral spots on the abdomen and these average 0.4 (range 0–4). The average number of femoral pores on the left leg is 13 (range 10–17). Females and some males develop a red-orange pattern on their throat and neck during the breeding season.

*Plateau spot-tailed earless lizard (Toby J. Hibbitts)*

*Tamaulipan spot-tailed earless lizard (Toby J. Hibbitts)*



plateau spot-tailed earless lizard
Tamaulipan spot-tailed earless lizard
*Holbrookia lacerata* and *subcaudalis*

### Identification cont.
**Tamaulipan spot-tailed earless lizard**: This is a small, earless lizard with an average of 5 (range 1–10) black spots on the underside of the tail. The average SVL is 56 mm (2.2 in.; range 31–72 mm [1.2–2.8 in.]), and the paravertebral and dorsolateral body blotches are often separated. An average of 0.7 (range 0–6) out of an average of 6 (range 4–9) blotches are fused. The blotches form four rows of transverse mostly circular blotches. The dark blotches on the rear legs are circular in shape and do not form into bands. The average number of leg blotches is 8 (range 4–14). Most individuals have black lateral spots on the abdomen and these average 2.6 (range 0–5). The average number of femoral pores on the left leg is 14 (range 10–19). Females are greenish yellow during the breeding season but neither sex acquires orange on the throat.

### Habitat
From TPWD's Rare, Threatened, and Endangered Species of Texas database (2021): Terrestrial; Habitats include moderately open prairie-brushland regions, particularly fairly flat areas free of vegetation or other obstructions (e.g., open meadows, old and new fields, graded roadways, cleared and disturbed areas, prairie savanna, and active agriculture including row crops); also, oak-juniper woodlands and mesquite-prickly pear associations.

### Distribution
The plateau spot-tailed earless lizard is found north of the Balcones Escarpment on the Edwards Plateau in Texas while the Tamaulipan spot-tailed earless lizard is found south of the Balcones Escarpment in southern Texas and northern Mexico.

### Management
Beneficial conservation actions include encouraging native grasslands, eradicating exotic species (particularly red imported fire ants and non-native grasses), and avoiding pesticides. Light grazing and lightly used roads within ranchland might be beneficial to the species.

### Surveys
Driving surveys along roads at slow speeds (e.g., 24 km/h [15 mph]) between 0900 and 1700 hrs appear to be more effective than visual encounter walking surveys (Hibbitts et al. 2021).

### Threats cited by USFWS (2011)
- Fire ant predation

## plateau spot-tailed earless lizard
## Tamaulipan spot-tailed earless lizard

*Holbrookia lacerata* and *subcaudalis*

### Threats cited by Duran (2017)

- Urbanization and roads
- Invasive species (mostly red imported fire ants and exotic grasses)
- Conversion of grasslands to agriculture and other uses

### Potential mitigation/translocation/propagation actions

Unknown

### References

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Hibbitts, T. J., D. K. Walkup, T. J. LaDuc, B. D. Wolaver, J. P. Pierre, M. Duran, D. Neuharth, S. Frizzell, C. S. Adams, T. E. Johnson, D. Yandell, and W. A. Ryberg. 2021. Natural history of the spot-tailed earless lizards (*Holbrookia lacerata* and *H. subcaudalis*). Journal of Natural History 55:495–514. https://doi.org/10.1080/00222933.2021.1907469



## plateau spot-tailed earless lizard
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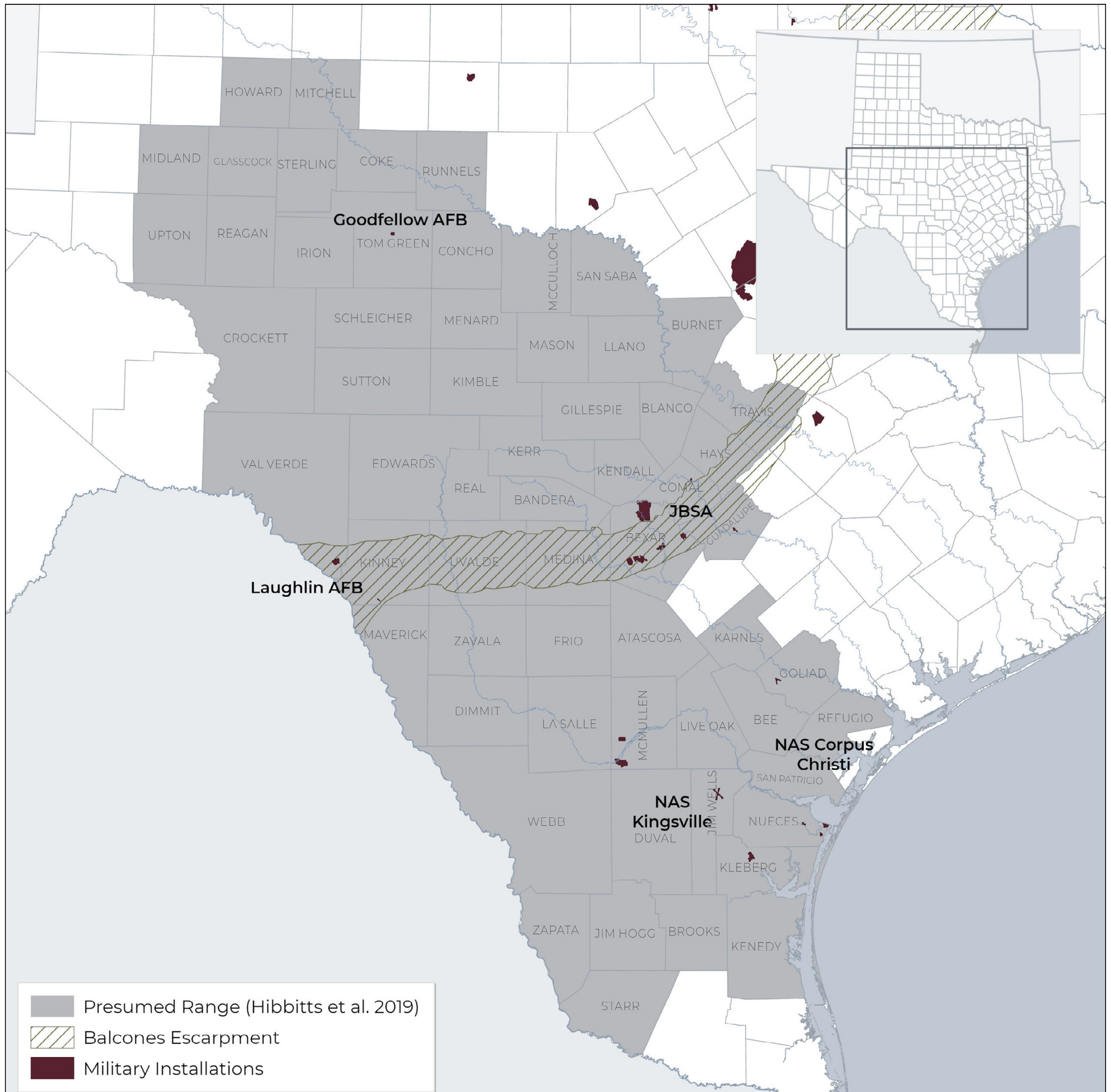
*Holbrookia lacerata* and *subcaudalis*

### References cont.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 90-day finding on a petition to list the spot-tailed earless lizard as endangered or threatened. Federal Register 76:30082–30087. https://www.federalregister.gov/documents/2011/05/24/2011-12752/endangered-and-threatened-wildlife-and-plants-90-day-finding-on-a-petition-to-list-the-spot-tailed

## plateau spot-tailed earless lizard
## Tamaulipan spot-tailed earless lizard
*Holbrookia lacerata* and *subcaudalis*




## Rio Grande cooter
*Pseudemys gorzugi*

### ESA Status
Under review, on current 5-year workplan for FY21. In 2015, USFWS found that listing the species may be warranted.

### Identification
Adults range from 18–32 cm (7.1–12.6 in.) in carapace (dorsal shell) length. Carapace dark green to black, with alternating yellow and black blotches, a slight keel, and serrated posterior edge. The second costal (lateral) scute has four distinct blotches with concentric black and yellow rings. The distal edges of the carapace are often reddish. The plastron (ventral shell) is yellow to red, but color may fade with age. Head, neck, and legs are dark with pale yellow stripes that may change to red on the feet and tail. A yellow oval blotch occurs behind the eyes on the side of the head, with bold striping curving dorsally over the blotch. Medial dorsal yellow line from snout to neck.

### Habitat
From TPWD's Rare, Threatened, and Endangered Species of Texas database (2021): Aquatic: Habitat includes rivers and their more permanent spring-fed tributary streams, beaver ponds, and stock tanks. Occupied waters may have a muddy, sandy, or rocky bottom, and may or may not contain aquatic vegetation.

*Pseudemys gorzugi (Toby J. Hibbitts)*

### Distribution
Found in the Rio Grande drainage, from the Pecos River in New Mexico to its confluence with the Rio Grande in Texas and down into the lower Rio Grande Valley, including tributaries like the Devil's River.

### Management
Unknown

### Surveys
Drone, visual, trapping, and environmental DNA (eDNA) surveys are all options for this species and are discussed in Bogolin (2020) and Davis (2019). An ideal study would incorporate multiple sampling methodologies, but this of course will depend upon available resources and the objectives of the study.

### Threats cited by USFWS (2015)
- Present or threatened destruction, modification, or curtailment of its habitat or range
- Commercial collection for the pet trade
- Recreational collection for pets
- Inadequacy of existing regulatory mechanisms

### Potential mitigation/translocation/propagation actions
Unknown

## Rio Grande cooter
*Pseudemys gorzugi*


### References

Bogolin, A. P. 2020. Comparing novel and traditional sampling methodologies to analyze the population status of the Rio Grande cooter (*Pseudemys gorzugi*). Thesis, University of Texas Rio Grande Valley, TX. https://search.proquest.com/docview/2423111659?pq-origsite=gscholar&fromopenview=true

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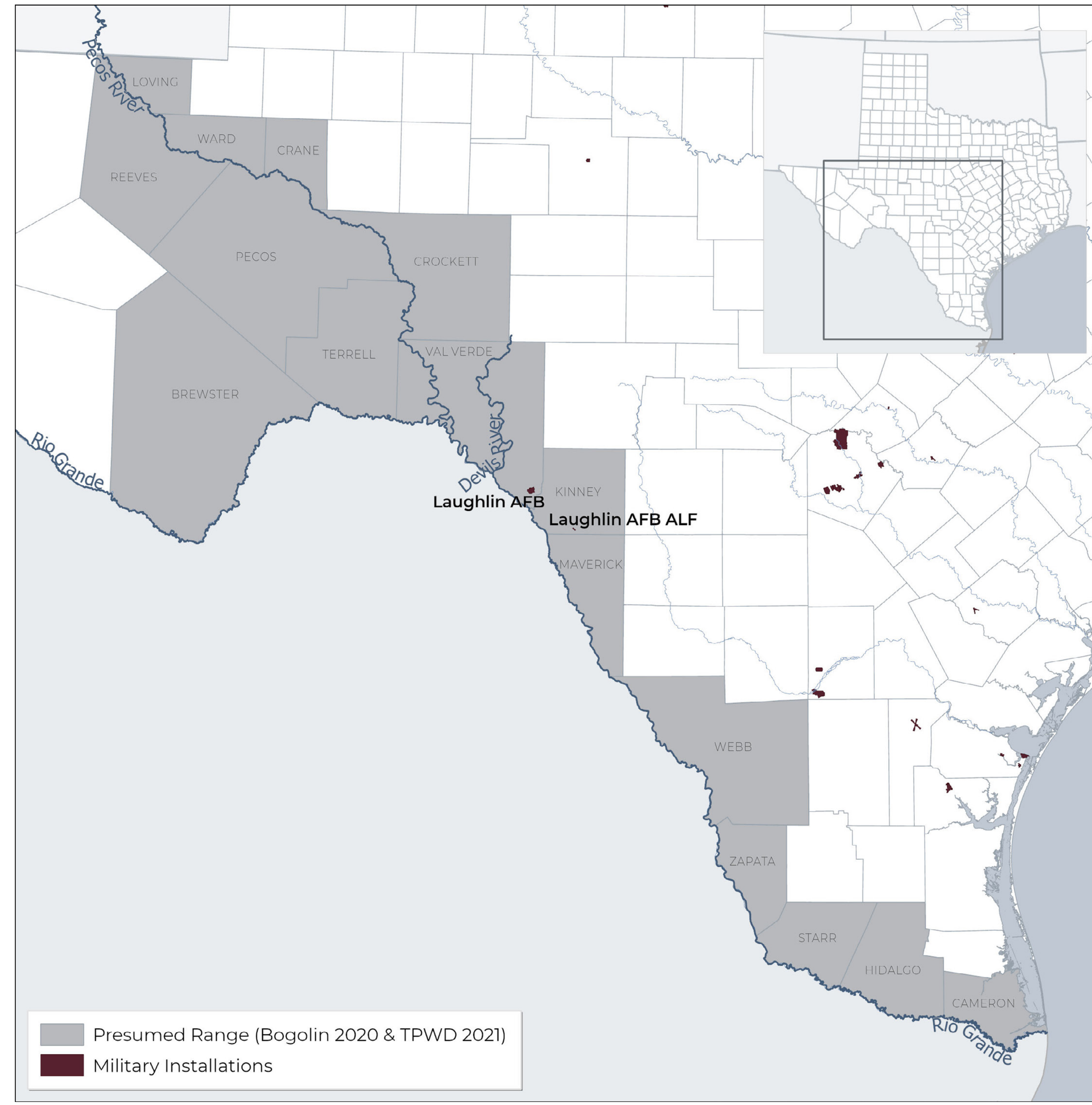
## Rio Grande cooter
*Pseudemys gorzugi*

## western chicken turtle

*Deirochelys reticularia miaria*

### ESA Status

Under review, not on current 5-year workplan. In 2011, USFWS found that listing the subspecies may be warranted.

### Identification

Adult carapace (dorsal shell) length 10–25 cm (4–10 in.), sexually dimorphic with males smaller than females. Dark green, olive, or brown carapace and a yellow plastron (ventral shell), with dark spots or bars on the bridge (side connections between top and bottom of shell). Rear margin of the carapace is smooth. Wide yellow longitudinal stripes on front legs and vertical yellow "pinstripes" on rump. Extremely long necks, can extend to about 70% of the turtle's shell.

### Habitat

In Texas, western chicken turtles usually live in ephemeral wetlands from February to July, then migrate to upland estivation sites and bury underground for the remainder of summer, fall, and winter. They prefer shallow, still, gently sloping wetlands that dry up from time to time. Dense aquatic vegetation is an important component of their habitat; they are most common in wetlands where at least 50% of the wetland contains dense vegetation. Though they will occasionally use roadside ditches when traveling from wetland to wetland, they are not usually found in the moving waters of streams, creeks, or rivers. For most of the year, western chicken turtles are underground

*Deirochelys reticularia miaria (Toby J. Hibbitts)*

at upland estivation sites. They bury themselves completely, and often dig beneath dense, thorny vines or shrubs for extra protection while they are estivating. Estivation sites can be over 500 m (547 yd.) from wetland habitat. (https://nri.tamu.edu/learning/wildlife/about-the-western-chicken-turtle/; Bowers et al. 2019).

### Distribution

This subspecies' range covers eastern Texas, Louisiana, and parts of Oklahoma and Arkansas, and is rarely found in Missouri (and potentially Mississippi; Powell et al. 2016). They are historically known from 53 counties in eastern Texas. The map included displays counties with mean and maximum modeled probability of occurrence >50% (Ryberg et al. 2017).

### Management

Ryberg et al. (2017) suggested expanding the definition of hydrologic connectivity to include biological connectivity of wetlands to provide protection of high-quality habitat under the U.S. Clean Water Act.

### Surveys

In Texas, surveys should be conducted from April to June in years with average rainfall. Surveys can include dipnet surveys, night wading surveys, and using fyke nets. From Bowers et al. (2019): "When designing a chicken turtle





### Surveys cont.

study that requires active surveys, the best survey method choice varies depending on research questions, budget, and time constraints. Capture rates were highest using dipnet surveys, but turtles captured during dipnet surveys were significantly smaller than turtles captured during wading surveys and fyke net sessions. Because most capture-mark-recapture study procedures assume equal catchability of individuals within a population, a combination of fyke net traps and dipnet surveys are recommended to encompass the range of chicken turtle sizes, unless property access prohibits the deployment of traps. In such cases, a combination of wading surveys and dipnet surveys is recommended."

### Threats cited by USFWS (2011)

- Present or threatened destruction, modification, or curtailment of its habitat or range
- Overutilization for commercial, recreational, scientific, or educational purposes
- Inadequacy of existing regulatory mechanisms
- Other natural or manmade factors

### Threats cited by Ryberg et al. (2017)

- Wetland loss and fragmentation in urban and urbanizing rural areas, particularly around Houston

### Potential mitigation/translocation/propagation actions

Unknown

### References

Bowers, B. C., D. K. Walkup, T. J. Hibbitts, and W. A. Ryberg. 2019. Movements, home range, activity patterns, and habitat selection of the western chicken turtle (*Deirochelys reticularia miaria*) in Texas. Final report submitted to Texas Parks and Wildlife Department.

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## western chicken turtle
*Deirochelys reticularia miaria*


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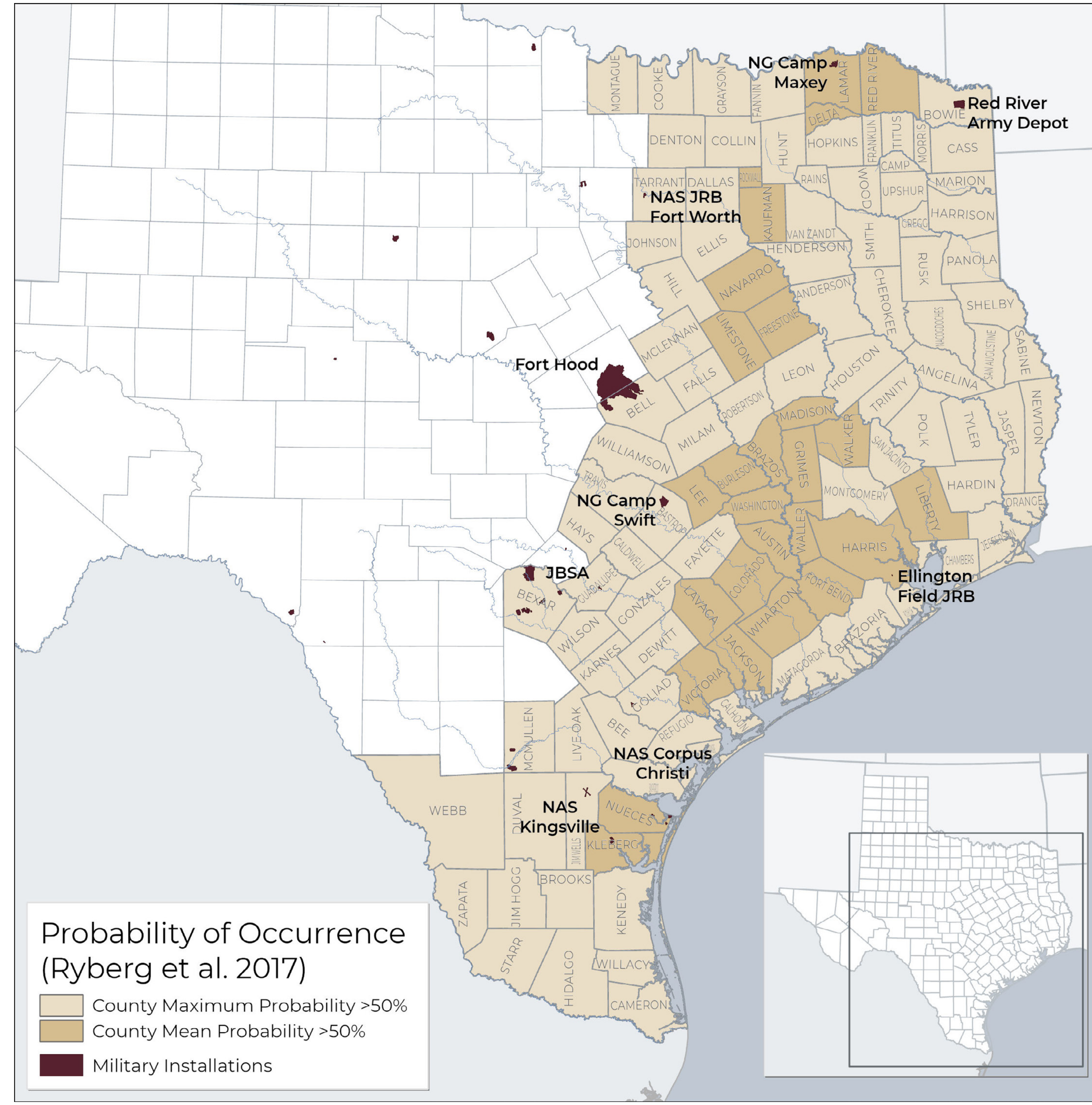
## western chicken turtle
*Deirochelys reticularia miaria*

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