RECOVERY PLAN FOR
TEXAS SNOWBELLS
(*STYRAX PLATANIFOLIUS* SSP. *TEXANUS*)

DRAFT REVISION

Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, NM

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The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), requires the development of recovery plans for listed species, unless such a plan would not promote the conservation of a particular species. Recovery plans delineate such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of listed species. Plans are published by the U.S. Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies and others. Recovery plans do not necessarily represent the views, official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions. Please check for updates or revisions at the website below before using.

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The first uses of technical terms are dash-underlined, and are defined in the glossary on pages 13-14. For convenience, the first uses of scientific units are spelled out, and are also summarized on page 12.

Prepared by Chris Best, U.S. Fish and Wildlife Service, Austin Ecological Services Field Office.

I. Introduction.

Texas snowbells is a rare, endemic shrub of the Edwards Plateau of Texas. On October 12, 1984, we listed Texas snowbells as an endangered species, *Styrax texanus*, under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq; Act).) (49 FR 40036). We currently recognize this plant as *S. platanifolius* ssp. *texanus*, one of five closely related subspecies described in the most recent taxonomic treatment (Fritsch 1997).

In 1987, the U.S. Fish and Wildlife Service (USFWS) finalized a recovery plan for Texas snowbells (USFWS 1987), however criteria for reclassifying the species to a threatened status (downlisting) or for removal from the endangered species list (delisting) were not established. This revised Recovery plan (Recovery Plan) takes into account the experiences and data acquired for Texas snowbells over the last three decades, and establishes criteria for downlisting and delisting.

We conducted a Species Status Assessment (SSA) of Texas snowbells (USFWS 2017), which is a thorough review of the subspecies' taxonomy, natural history, habitats, ecology, populations, and range. The SSA then analyzes individual, population, and subspecies requirements, factors affecting the subspecies' survival, and current conditions, to assess the subspecies' current and future viability in terms of resilience, redundancy, and representation. The SSA also includes conservation recommendations.

This streamlined Recovery Plan is derived from the SSA and focuses primarily on the elements required under section 4(f)(1)(B) of the Act:

(i) A description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;

(ii) objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and

(iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In cooperation with our partners, we have also prepared a Recovery Implementation Strategy (RIS), which serves as an operational plan for stepping down the higher-level recovery actions into specific tasks (USFWS 2018b). The RIS is a separate document from this Recovery Plan and can be modified if monitoring reveals that expected results are not being achieved, therefore maximizing flexibility of recovery implementation.

II. Overview

The following is a brief overview of the natural history and status of Texas snowbells. Please refer to the SSA Report (USFWS 2017) for discussion and complete literature citations.

Texas snowbells (*Styrax platanifolius* ssp. *texanus*, Styracaceae) is a multi-stemmed shrub or small tree up to 6 meters (m) (20 feet [ft]) tall. The subspecies has been found only along canyons and ravines of 1st-, 2nd-, and 3rd-order streams in the upper Nueces, West Nueces, and Devils River in the Edwards Plateau of Texas (Figure 1). Naturally occurring populations have not been documented elsewhere, but could persist in the Sycamore Creek, Frio River, West Frio River, or other adjacent watersheds. The range extends 121 kilometers (km) (75 miles [mi]) east to west and 35 km (22 mi) north to south. Populations occur in limestone geological formations; annual precipitation ranges from 51.3 centimeters (cm) (20.2 inches [in]) to 69.5 cm (27.4 in); average temperatures range from a minimum of 0.9° Celsius (C) (33.6° Fahrenheit [F]) in January to a maximum of 36.3° C (97.3° F) in July; and elevations range from 372 to 579 m (1,220 to 1,900 ft).

By 2013, 400 mature and 452 immature Texas snowbells plants had been documented in 22 naturally-occurring sites. Fifteen of the documented sites had fewer than 10 individuals and 2 had at least 100. Fifteen naturally occurring populations are on private land, 5 are on private conservation land (Dolan Falls Preserve and conservation easements managed by The Nature Conservancy), and 2 are on public conservation land (Devil's River State Natural Area). The subspecies has also been reintroduced in 22 sites on private land and 2 sites at Dolan Falls Preserve.

A preliminary study (Fulton 2010) found that the breeding system is obligately xenogamous (self-incompatible), and effective pollinators include the honey bee (*Apis mellifera*), American bumble bee (*Bombus pensylvanicus*), and California carpenter bee (*Xylocopa californica*). Sexual fertilization requires the transfer of pollen between genetically compatible individuals that are within the foraging range of suitable pollinators; effective pollination probably occurs most often between individuals that are not more than 0.5 km (0.3 mi) apart, but in rare cases pollen transfer could occur over 5 km (3.1 mi) or greater distances. Closely related individuals, such as the progeny of a single pair of plants, may not be able to fertilize each other's flowers, and small populations may not have sufficient genetic diversity for sexual reproduction to occur. Although we do not know how many individuals are required for effective reproduction, or how widely dispersed they may be, almost all documented reproduction of Texas snowbells in the wild occurs among populations that have at least 56 mature individuals dispersed over a distance of 1.6 km (1.0 mi) or less.

Mortality of seedlings and juvenile plants is high and largely due to browsing by dense populations of native white-tailed deer (*Odocoileus virginianus*) and introduced ungulates. Texas snowbells plants begin reproducing at about 10 years of age, and if not severely browsed, may live for many decades.

A large proportion of the potential habitat of Texas snowbells is privately owned and can only be accessed with landowner permission. Much of the potential habitat on private land has probably

not been surveyed. Therefore, we believe that the actual size and numbers of populations and the degree of connectivity between them may be greater than the data from documented populations indicates.

Our assessment of species viability, defined as the likelihood of persistence over the long-term, is based on the concepts of resilience, redundancy, and representation. Texas snowbells has a low level of resilience because all known populations are far below the estimated minimum viable population level. There are few populations, hence redundancy is low. The subspecies is endemic to a small area with little ecological differentiation, and has little genetic diversity and therefore has low representation. In synthesis, the viability of Texas snowbells is low.

Recovery Vision.

The recovery goal is the conservation and survival of Texas snowbells. Recovery will be signified by: Resilient, redundant, viable metapopulations in the Nueces, West Nueces, and Devils River watersheds (and possibly other watersheds, if other naturally-occurring populations are discovered), where spontaneous recruitment over time equals or exceeds mortality; and the conservation of its ecological and genetic representation through the restoration of gene flow throughout each extant metapopulation.

Recovery Strategy.

Populations are considered resilient when they are sufficiently large to endure stochastic changes. We have provisionally estimated a minimum viable population (MVP) size of 500 to 1,000 individuals. However, since suitable habitats are narrow, discontinuous patches distributed along ravines and watercourses, only a small fraction of this MVP could occur in any one place. Therefore, we recommend that this MVP be applied to metapopulations consisting of numerous interacting colonies within a single watershed.

Resilient populations must also have stable or increasing demographic trends over time. This means that recruitment of new individuals is at least as great as mortality. Hence, viable populations must have sufficient numbers of individuals that are not too closely related or too widely dispersed for effective pollination and seed production. Empirically, we judge that effective reproduction occurs when colonies have at least 50 individuals that are separated by not more than 0.5 km (0.3 mi). This may be accomplished by augmenting small populations to increase their size and genetic diversity, thereby increasing the fertilization rate of flowers and the production of viable seeds; and also by reintroducing populations to restore gene flow between isolated individuals and small populations through the transfer of pollen between and among them. We predict that the strategic placement of reintroduced plants to restore population connectivity will be of greater benefit to the subspecies' viability than solely increasing population sizes without increasing connectivity.

Effective reproduction also depends on healthy populations of native bee species. Texas snowbells populations occur in fairly remote areas where there has been little development or intensive agriculture, and bee populations are presently secure. Nevertheless, many native bee

species have declined in recent decades, so pollinator conservation, monitoring, and awareness should be promoted within the range of Texas snowbells (and elsewhere).

Successful recruitment of Texas snowbells also depends on reducing mortality from browsing. As a temporary measure, isolated individuals, small colonies, and reintroduced plants may be protected from browsing with deer fencing or barriers of cut junipers. However, the long-term recovery of dynamic populations, where recruitment is not constrained within fenced areas, will require reduced browsing and effective management of white-tailed deer and introduced ungulates.

The redundancy of Texas snowbells will be maintained by conserving viable wild metapopulations in each watershed where it occurs. This includes the upper watersheds of the Nueces, West Nueces, and Devils Rivers but could also include the Frio, West Frio, Dry Frio, or Sycamore Creek watersheds if natural populations are discovered there. Each metapopulation should be managed as a separate recovery unit (Figure 1), since each is essential for the subspecies' recovery, and the loss of any one would further reduce its limited redundancy.

The ecological and genetic representation of Texas snowbells will be maintained through conservation of all of its metapopulations, and will be improved through the restoration and enhancement of gene flow, by means of pollination or seed dispersal, between and within the colonies of a metapopulation. As described above, this may be accomplished through the augmentation of small colonies and the reintroduction of populations that link isolated individuals and colonies.

Since much of the subspecies' range and potential habitats occur on privately owned lands, recovery depends largely on the voluntary cooperation and participation of private landowners. A group of cooperating landowners and volunteers, led by Mr. J.D. Bamberger, has already made significant progress toward accomplishing recovery objectives. Landowner outreach, therefore, is an essential, overarching tool for accomplishing all other recovery objectives.

The time frame required to improve the viability of Texas snowbells is influenced largely by its life history. When all conservation actions have been accomplished, their effectiveness will be measured by the natural recruitment of new individuals, their growth to maturity, and the increase of populations to a viable level that is sustained without further human intervention (other than appropriate habitat management, deer and other ungulate population management, and pollinator conservation). Since the minimum time required to complete one generation in the wild is 10 years, the criteria for downlisting and delisting have time frames in units of 10-year spans.

III. Prioritized Recovery Actions.

The following is a list of prioritized actions, including site-specific management actions, that when fully implemented are expected to result in recovery of Texas snowbells. Priority 1 actions are defined as those actions that must be taken to prevent extinction or to prevent the subspecies from declining irreversibly in the foreseeable future. Priority 2 actions are those that must be taken to prevent a significant decline in population size or habitat quality or some other significant negative impact. Priority 3 actions are all other actions that are necessary to provide for full recovery of the subspecies. The assignment of priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented. Please refer to Table 1 for a clear association among recovery actions and the threats addressed by these actions. Specific tasks required to implement these recovery actions are detailed in the RIS (USFWS 2018b).

Priority 1.

1. Promote awareness and conservation of Texas snowbells on private lands in the upper Nueces, West Nueces, and Devils River watersheds, as well as other watersheds if natural populations are discovered there.

2. Protect remnant populations and individuals of Texas snowbells from ungulate browsers, and reduce browse intensity through population management of native white-tailed deer and introduced ungulates in the upper Nueces, West Nueces, and Devils River watersheds.

3. Conduct scientific investigations to guide conservation efforts.

Priority 2.

4. Augment small populations and isolated individuals to increase reproductive rates, and reintroduce populations to restore gene flow between and among remnant populations in the upper watersheds of the Nueces, West Nueces, and Devils Rivers. Augmentation and reintroduction may also be appropriate in the Frio, West Frio, Dry Frio, and Sycamore Creek watersheds if natural populations are confirmed there, but is contra-indicated if other subspecies of *Styrax platanifolius* occur there, since this could lead to hybridization between subspecies.

Priority 3.

5. Search for new populations in potential habitats throughout the subspecies' range. In particular, the discovery or confirmation of populations in the Frio, West Frio, Dry Frio, or Sycamore Creek watersheds would increase our knowledge of the subspecies' geographic range and adaptability, and might confer greater ecological and genetic diversity (representation) to the subspecies as a whole.

6. Promote conservation and management of native bees, butterflies, and other pollinators in the upper Nueces, West Nueces, and Devils River watersheds.

7. Verify that viable, self-sustaining populations occur within each recovery unit (shown in Figure 1) and have maintained stable or increasing population sizes for three or more generations (a minimum of 30 years). One generation has passed when individuals are successfully recruited through seed germination within habitats, survive to maturity, produce viable seed, and the second-generation seed germinates in the same habitats. Based on observed growth rates in the wild, a single generation takes at least 10 years to complete.

IV. Recovery Criteria.

IV.1. Downlisting Criterion.

Texas snowbells may be reclassified as a threatened species when the following conditions have been met:

Self-sustaining metapopulations have reached the MVP level of at least 500 individuals of reproductive age in each recovery unit (occupied watershed, shown in Figure 1): The upper Nueces, West Nueces, and Devils River. If wild populations are discovered in other watersheds, this criterion must also be met in those watersheds. MVP is based only on mature, reproductive individuals since mortality of young Texas snowbells plants is very high, and apparent population sizes can fluctuate wildly if immature plants are included. Metapopulations may be considered self-sustaining when:

a) Unaided recruitment equals or exceeds mortality over a 10-year span, which is the expected minimum time to complete an entire generation (as defined in III.7);

b) facilitated population augmentation and reintroduction are no longer necessary for successful recruitment; and

c) fenced exclosures or other types of barriers are no longer necessary to reduce mortality from ungulate browsing.

However, we anticipate that population management of white-tailed deer and introduced ungulates, pollinator conservation, and other habitat management practices will continue to be necessary in this region. The continuation of these practices will not preclude the attainment of this criterion.

IV.2. Delisting Criterion.

Texas snowbells may be removed from the endangered species list when:

All downlisting criteria (IV.1.a. b, and c) have been met and sustained, and self-sustaining metapopulations have been established in each recovery unit (occupied watershed) and have remained stable or increasing for 20 additional years (2 additional generations, as described in III.7); this is a total of at least 30 years (3 generations). The completion of 3 generations would likely span multiple periods of high and low precipitation. This represents the minimum number of generations required to detect demographic trends; however, a longer time frame may be necessary if a clear trend has not yet been observed.

Table 1. Factors affecting the survival of Texas snowbells (U.S. Fish and Wildlife Service 2017) and associated recovery actions and criteria.

ESA Listing Factors		Threats Description	Recovery Actions	Recovery Criteria
Factor A	The present or threatened destruction, modification, or curtailment of its habitat or range	Severe Floods	3, 4, 7	III.1.1.a.
Factor C	Disease or predation	Severe browsing by white-tailed deer and introduced ungulates	1, 2, 7	III.1.1.c.
Factor E	Other natural or manmade factors affecting its continued existence	Small population sizes	1, 2, 3, 4, 5, 7	III.1.1.a, b.
		Lack of genetic diversity	3, 4, 5, 7	III.1.1.a, b.
		Population fragmentation and isolation	1, 3, 4, 5, 7	III.1.1.a, b.
		Pollinator deficiency	3, 6, 7	III.1.1.a, b.
		Climate changes	3, 4, 7	III.2.

V. Estimated time and costs to achieve recovery.

Tables 2 and 3 summarize the estimated time and costs to achieve the recovery of Texas snowbells. These tables are derived from the more detailed (activity-level) estimates of time and costs shown in the Recovery Implementation Strategy. Costs include financial as well as volunteer and in-kind support. Table 2 shows only the actions to be implemented specifically for the recovery of Texas snowbells. Table 3 includes estimates of ongoing or future conservation programs that are supported by other agencies and have other primary objectives (deer and ungulate herd management and pollinator conservation), but that would also contribute to Texas snowbells recovery. These estimates include actions that took place prior to 2017 when the current, revised Recovery Plan was prepared. We estimate that the full implementation of these actions would improve the status of Texas snowbells so that it could be reclassified as a threatened species (criterion IV.1) after the span of an entire generation (at least 10 years), following the adoption of this plan. The persistence of viable, self-sustaining populations (criterion IV.2) would be assessed during the following two generations. Table 2 projects estimated costs through years 30 to 50 (or beyond, as described above).

Table 2. Estimated time and costs of conservation programs specifically for recovery of Texas snowbells.

	Costs ($1,000s) and Time Frames (Years)							
Action	**Prior to 2017[1]**	**1-5**	**6-10**	**11-15**	**16-20**	**20-30**	**30-50**	**Total**
1	75.0	51.0	51.0	51.0	51.0	51.0	51.0	381.0
2	10.0	10.0	10.0	10.0	10.0	0.0	0.0	50.0
3	115.0	225.0	0.0	0.0	0.0	0.0	0.0	340.0
4	125.0	169.0	125.0	80.0	80.0	20.0	30.0	629.0
5	20.0	20.0	20.0	20.0	20.0	0.0	0.0	100.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	120.0	120.0
Totals:	**345.0**	**475.0**	**206.0**	**161.0**	**161.0**	**71.0**	**201.0**	**1,620.0**

[1] Actions completed under the original recovery plan (USFWS 1987).

Table 3. Estimated time and costs of other conservation programs that will contribute to the recovery of Texas snowbells.

	Costs ($1,000s) and Time Frames (Years)							
Action	**Prior to 2017[1]**	**1-5**	**6-10**	**11-15**	**16-20**	**20-30**	**30-50**	**Total**
2	n/a	250.0	250.0	250.0	250.0	250.0	250.0	1,500.0
6	60.0	60.0	60.0	60.0	60.0	60.0	60.0	420.0
Totals:	**60.0**	**310.0**	**310.0**	**310.0**	**310.0**	**310.0**	**310.0**	**1,920.0**

[1] Actions completed under the original recovery plan (USFWS 1987).

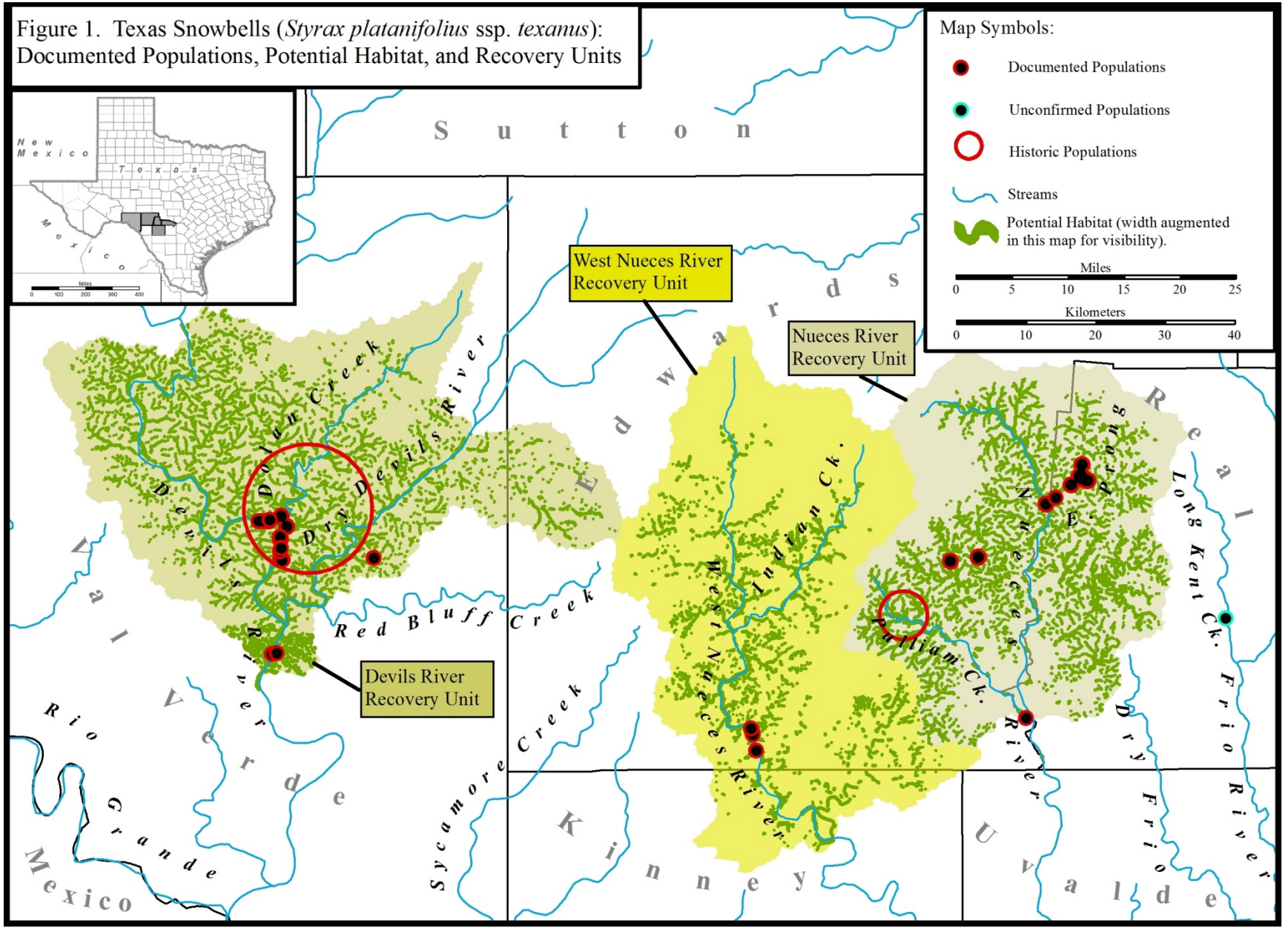
Figure 1. Texas Snowbells (*Styrax platanifolius* ssp. *texanus*): Documented Populations, Potential Habitat, and Recovery Units
New Mexico
Texas
Mexico
Miles
0 100 200 300 400
Map Symbols:
Documented Populations
Unconfirmed Populations
Historic Populations
Streams
Potential Habitat (width augmented in this map for visibility).
Miles
0 5 10 15 20 25
Kilometers
0 10 20 30 40
West Nueces River Recovery Unit
Nueces River Recovery Unit
Devils River Recovery Unit
Sutton
Edwards
Real
Val Verde
Kinney
Uvalde
Mexico
Rio Grande
Devils River
Dolan Creek
Dry Devils River
Red Bluff Creek
Sycamore Creek
West Nueces River
Indian Ck.
Pullian Ck.
Nueces River
Dry Frio River
Long Kent Ck.
Frio River

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Scientific Units.

° C	Celsius degrees	in	Inches
cm	Centimeters	km	Kilometers
° F	Fahrenheit degrees	m	Meters
ft	Feet	mi	Miles

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Glossary.

Term	Definition
Endemic	An organism restricted to a specific habitat or geographic range.
Metapopulation	A group of spatially separated populations of the same species that interact at some level (Wikipedia 2017).
Minimum viable population	The fewest individuals required for a specified probability of survival over a specified period of time (Pavlik 1996; Mace and Lande 1991).
Redundancy	The number of populations or sites necessary to endure catastrophic losses (Shaffer and Stein 2000, pp. 308-310).
Representation	The genetic diversity necessary to conserve long-term adaptive capability (Shaffer and Stein 2000, pp. 307-308).
Resilience	The size of populations necessary to endure random environmental variation (Shaffer and Stein 2000, pp. 308-310).
Species viability	A species' ability to sustain populations in the wild beyond the end of a specified time period, assessed in terms of its resilience, redundancy, and representation (USFWS 2015).
Stochastic	Random.
Strahler stream order	First-order streams are the outermost tributaries of a stream. Two streams of the same order join to form a stream of the next highest order (two first-order streams form a second-order stream). Two streams of different order merge and continue with the order of the higher of the two (a second- and third-order stream merge and continue as a third-order stream) (Wikipedia 2017).
Subspecies	A taxonomic group that is a division of a species; usually arises as a consequence of geographical isolation within a species (Biology-online.org 2011).
Taxonomy	Scientific classification of living organisms.
Ungulate	In the broad sense, hooved mammals.
Watershed	A physiographic area bound by a drainage divide and within which precipitation drains to a point of interest (NRCS 1999-Present).
Xenogamy	Sexual fertilization between different, unrelated individuals.

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