U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT
AND LISTING PRIORITY ASSIGNMENT FORM
March 14, 2023

SCIENTIFIC NAME: *Phreatodrobia imitata*

COMMON NAME: Mimic cavesnail

LEAD REGION: 2

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DATE INFORMATION CURRENT AS OF: September 2023

STATUS/ACTION

___Species petitioned for listing which we have determined is not a listable entity

_X_ Species petitioned for listing which we have determined does not warrant listing (does not meet the definition of a threatened or endangered species)

___Non-listed species for which we have not received a petition but for which we have undertaken a species status assessment on our own initiative and which we have determined does not warrant listing (does not meet the definition of a threatened or endangered species)

Petition Information:
___ Non-petitioned
_X_ Petitioned; Date petition received: 6/25/2007
90-day "substantial" finding FR publication date; citation: 12/16/2009, 74 FR 66866

PREVIOUS FEDERAL ACTIONS:

On June 25, 2007, the U.S. Fish and Wildlife Service (Service) received a petition dated June 18, 2007, from Forest Guardians (i.e., WildEarth Guardians) requesting that the Service list 475 species, including the mimic cavesnail (Forest Guardians 2007, p. 19), as a threatened or endangered species and designate critical habitat under the Endangered Species Act (Act). All 475 species occur within the Southwestern Region and were ranked as G1 or G1G2 species by NatureServe at the time. In a July 11, 2007, letter to the petitioner, the Service acknowledged receipt of the petition and stated that the petition was under review by staff in the Southwest Regional Office. On December 16, 2009, the Service published a partial 90-day finding on the mimic cavesnail and 191 other species, stating that the petition presented substantial scientific information indicating that listing may be warranted for 67 of the 192 species, including the mimic cavesnail (74 FR 66866). This document constitutes our 12-month finding on the June 25, 2007, petition to list mimic cavesnail under the Act.

ANIMAL GROUP AND FAMILY: Snails, Hydrobiidae

ANALYTICAL FRAMEWORK

To assess the viability of the mimic cavesnail, we conducted a species status assessment (SSA) using the three conservation biology principles of resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 306–311). Briefly, resiliency supports the ability of the species to withstand environmental and demographic stochasticity (for example, wet or dry, warm or cold years, variation in demographic rates), redundancy supports the ability of the species to withstand catastrophic events (for example, droughts, large pollution events), and representation supports the ability of the species to adapt to both near-term and long-term changes in its physical and biological environment (for example, climate change, disease). A species with a high degree of resiliency, representation, and redundancy is better able to adapt to novel changes and to tolerate environmental stochasticity and catastrophes. In general, species viability will increase with increases in resiliency, redundancy, and representation (Smith et al. 2018, p. 306). Using these principles, we identified the species' ecological requirements for survival and reproduction at the individual, population, and species levels, and described the beneficial and risk factors influencing the species' viability.

We use the SSA framework to assemble the best scientific and commercial data available for this species. The SSA framework consists of three sequential stages. During the first stage, we evaluate the species' needs. The next stage involves an assessment of the historical and current condition of the species' demographics and habitat characteristics, including an explanation of how the species arrived at its current condition (i.e., how threats and conservation actions have influenced the species). The final stage of the SSA framework involves assessing the species' plausible range of future responses to positive and negative environmental and anthropogenic influences. The SSA framework uses the best available information to characterize viability as the ability of a species to sustain populations in the wild over time and is used to inform our regulatory decision.

The SSA report does not represent a decision by the Service on whether the mimic cavesnail should be listed as an endangered or threatened species under the Act. However, it does provide the scientific basis that informs our regulatory decisions, which involve the further application of standards within the Act and its implementing regulations and policies. The Species Status Assessment Report for the Mimic Cavesnail (*Phreatodrobia imitata*) [November 2022, Version 1.0] (SSA Report) is a summary of the information we have assembled and reviewed and incorporates the best scientific and commercial data available for this species. Excerpts of the SSA report are provided in the sections below. For more detailed information, please refer to the SSA report (Service 2022, entire).

BIOLOGICAL INFORMATION

The mimic cavesnail is a freshwater snail endemic to a deep portion of the Edwards Aquifer in Bexar County, Texas. It is a very small snail, with average shell height of about 1.0 millimeters (mm) [0.04 inches (in)], a thin operculum, and trapezoidal radula. Freshwater gastropods are broadly characterized by rapid growth and short life spans which result in high reproduction rates and shorter rates of population turnover (Tallarico 2016, p. 331). Species may reproduce a single or multiple generations per year (Dillon 2004, pp. 156–162).

The range of the mimic cavesnail is the southwestern extent of the San Antonio-New Braunfels Metropolitan Area in Bexar County. The distribution of the mimic cavesnail is dependent upon the availability and connectivity of suitable aquatic subterranean habitat, with sufficient water quality and quantity within deep subterranean spaces. Prior to 1986, the mimic cavesnail was known from only two groundwater wells, O.R. Mitchell (State Well Number 6843601) and Verstraeten Wells (State Well Number 6843607) (Hershler and Longley 1986, pp. 151–152). In 2021, the species was discovered at Aldridge 209 Well (State Well Number 6843802) (Diaz 2021, pp. 31–32), which is five kilometers (km) [three miles (mi)] from the southwest of O.R. Mitchell and Verstraeten Wells. All mimic cavesnail wells occur just to the northwest of the freshwater/saline-water interface.

The mimic cavesnail has never been directly observed in its natural habitat but is thought to inhabit groundwater-filled voids of varying size in the rock layers that comprise the Edwards Aquifer. The spatial configuration (e.g., length and width) of potentially preferred water-filled void space is unknown. In general, physical space(s) used by this species likely consists of water-filled caverns, fissures, fractures, and other voids of varying diameters (Hershler and Longley 1986 p. 162). Because these snails are so minute (e.g., 1 mm (0.4 in) or less in diameter), they are likely capable of using very small diameter void space, especially juveniles.

We assume that the mimic cavesnail's life span is comparable to that of the enigmatic cavesnail and is at least three years in length. Because conditions of the deep aquifer are relatively stable compared to surface aquatic habitats, we would expect that mimic cavesnails likely reproduces throughout the year. Because food resources to support reproduction are likely relatively stable given presence of a chemolithoautotrophic food web, we also assume that abundances of mimic cavesnails in their subterranean habitat may be high. Freshwater gastropods are broadly characterized by rapid growth and short life spans which results in high reproduction rates and shorter rates of population turnover (Tallarico 2016, p. 331). Species may reproduce a single or multiple generations per year (Dillon 2004, pp. 156-162). Cochliopid species that inhabit spring systems typically reproduce several times during the spring to fall breeding season (Brown 1991, p. 292) and are sexually dimorphic, with females being characteristically larger and longer-lived than males (Hershler 1998, p. 10; Hershler 2001, pp. 3-5).

Evidence indicates that the subterranean habitat of the mimic cavesnail is a network of interconnected conduits, permitting the movement of individuals and facilitating gene flow. Subterranean networks of water-filled conduits can facilitate stygobiont gene flow across karst systems. Research from karstic systems of eastern Europe documented 34-38 km (21-24 mi) subterranean dispersal corridors for several stybobiont snail species (Falniowski et al. 2021, pp. 4,979-4,980, 4,985-4,986; Grego and Pešić 2021, pp. 68, 73-74). The mimic cavesnail likely exists as a single sympatric subterranean population. The mimic cavesnail inhabits a portion of the aquifer with significant groundwater flow and extensive cavernous openings.

For additional information on the species description, taxonomy, historical and current range/distribution please refer to pp. 8–20 of the SSA report. For additional information on habitat/life history and population and species needs, please refer to pp. 21–28 of the SSA report.

FACTORS INFLUENCING THE STATUS

The Act directs us to determine whether any species is an endangered species or a threatened species because of any factors (or threats) affecting its continued existence (i.e., whether it meets the definition of a threatened species or an endangered species). We use the term "threat" to refer in general to actions or conditions that are known to or are reasonably likely to negatively affect individuals of a species. The term "threat" includes actions or conditions that have a direct impact on individuals, as well as those that affect individuals through alteration of their habitat or required resources. The term "threat" may encompass—either together or separately—the source of the action or condition, or the action or condition itself.

However, the mere identification of any threat(s) does not necessarily mean that the species meets the statutory definition of an "endangered species" or a "threatened species." In determining whether a species meets either definition, we must evaluate all identified threats by considering the expected response by the species, and the effects of the threats—in light of those actions and conditions that will ameliorate the threats—on an individual, population, and species level. We evaluate each threat and its expected effects on the species, then analyze the cumulative effect of all of the threats on the species as a whole. We also consider the cumulative effect of the threats in light of those actions and conditions that will have positive effects on the species—such as any existing regulatory mechanisms or conservation efforts. The Secretary determines whether the species meets the definition of an "endangered species" or a "threatened species" only after conducting this cumulative analysis and describing the expected effect on the species now and (if evaluating whether a species is a threatened species) in the foreseeable future.

Threats, Conservation Measures, and Existing Regulatory Mechanisms

Mortality from Groundwater Wells

The existence of the mimic cavesnail has been documented through the collection of specimens expelled from groundwater wells. Wells eject both empty shells and live mimic cavesnails. Upon expulsion from wells, living mimic cavesnails likely perish because of physical damage sustained during transport to the surface and/or the inhospitable conditions at the surface (i.e., enclosed water transport and storage or discharge of pumped water to agricultural fields). In Bexar County, the drilling of wells to meet public supply and irrigation demands began in the late 1880s (Livingston 1936, p. 87; Petitt and George 1956, p. 44). Over 1,500 wells were drilled in Bexar County by 1953, with 250 wells being large capacity (i.e., 25–76 centimeters (cm) [10–30 in] in diameter) (Petitt and George 1956, p. 44; Maclay 1995, p. 43).

Until 1996, groundwater extraction in Bexar County was unregulated, with no restrictions on well capacities, amounts of water discharged from wells, or groundwater waste (Miller 2005, pp. 172–173; Gulley 2015, p. 2; Mace 2019, p. 208). From 1939–2000, annual groundwater withdrawals increased by an average of 5,550,660 m^3 (4,500 ac-ft) (Lindgren et al. 2004, pp. 35–36). As of September 28, 2022, the Texas Water Development Board (2022a, unpaginated) lists 307 active wells at depths of >300 meters (m) [>984 feet (ft)] that access the deep, pressurized artesian zone of the Edwards Aquifer in Bexar County. Once established, a functioning groundwater well creates a capture zone (i.e., zone of hydraulic containment): a three-dimensional region that contributes groundwater to that well (Environmental Protection Agency 2008, p. 1; Moreau et al. 2014, p. 4; Barlow et al. 2018, pp. 697–700).

No well that has produced mimic cavesnails has ever been subject to long-term sampling, so documentation of numbers over time does not exist. Long-term faunal sampling of wells in the artesian zone of the San Antonio segment is very rare (the San Antonio segment is the southernmost segment of the aquifer and occurs under San Antonio, Texas; it is also referred to as the southern segment). Multi-year well surveys could provide insight into how stygobiont (i.e., animals that are obligate residents and adapted to subterranean habitats) communities respond to pumping, as well as the influence that decreased or increased aquifer recharge has on species assemblages.

The invertebrate community sampled by a well could experience dramatic changes as high flow dislodges individuals from refugia, shunts others away from well capture zones, and instigates some to shelter in smaller void space. During lower flows, individuals may recolonize remote subterranean spaces, while others return to areas of greater groundwater movement. How high and low flows influence capture of mimic cavesnails at wells is unknown.

A species' susceptibility (e.g., benthic or pelagic) to well capture may also influence community dynamics (Hutchins et al. 2021, p. 13). Crawling, swimming, and/or passive drift with groundwater flow are the most likely avenues for stygobiont invertebrate movement in deep aquifers (Stumpp and Hose 2017, p. 3452). Living mimic cavesnails may be less at risk of capture by groundwater wells due to their benthic lifestyle. The mimic cavesnail's rapid growth, short life span, and high reproductive rates likely mean that mortality from well uptake will not have long-lasting repercussions, as recruitment of younger individuals will not be diminished. Additionally, the species diminutive size would allow it to inhabit very small void spaces that may minimize exposure to well capture. Stygobiont snails may adhere to rocky surfaces, embed in biofilms and other microbial material, or forage and shelter in very small diameter pores in honey-combed rock (Popa et al. 2019, p. 4; Brad et al. 2021, p. 3). The absence of a living snail could make empty shells more apt to transport by groundwater and expulsion by wells. Sampling of aquatic snails at springs can yield larger numbers of empty shells than live individuals (Kathryn Perez, pers. comm. 2022). The lack of reported data concerning mimic cavesnail catch composition (i.e., numbers of empty shells/live/recently dead individuals) constrains assessment of the impacts of groundwater well mortality as a stressor on this species' population.

Reductions in Groundwater Quantity

The Edwards Aquifer is a critical water resource for several municipalities in central and south-central Texas. The importance of the aquifer to human needs was recognized in the mid-1970s when the San Antonio segment was designated a sole-source aquifer under the Safe Drinking Water Act of 1974 (Miller 2005, pp. 169–171, 177, 180). The U.S. Environmental Protection Agency (2022) defines a sole-source aquifer as one that supplies at least 50% of the drinking water in its service area and no reasonably available alternative drinking water sources exist should the aquifer become contaminated.

Of the three counties (i.e., Bexar, Medina, and Uvalde) in the western portion of the San Antonio segment, the greatest volumes of groundwater have been discharged from Bexar County (Edwards Aquifer Authority 2020, pp. 4–5). If not replenished through recharge, groundwater discharged from wells and springs is removed from aquifer storage (i.e., total amount of water in aquifer) (Lindgren et al. 2004, p. 41). The San Antonio segment is estimated to contain 55,506,682,690 cubic meters (m^3) [45,000,000 acre-feet (ac-ft)], with 46,872,309,827 m^3 (38,000,000 ac-ft) of that amount in the artesian zone (Maclay 1995, p. 46). With absent or much reduced recharge, persistent groundwater removal would initially lead to a decline and/or cessation in spring flows (Lindgren et al. 2004, p. 41).

Recharge to the San Antonio segment takes place primarily through stream seepage and infiltration of rainfall (Maclay 1995, p. 31; Lindgren et al. 2004, pp. 27, 28–33; Schindel 2019, p. 10). Major drainage basins lose significant volumes (i.e., losing streams), and sometimes all their baseflow, to recharge features (e.g., caves, fractures, and sinkholes) as they cross the area where the porous and permeable Edwards Group is exposed at the surface (Maclay 1995, p. 31; Lindgren et al. 2004, pp. 31–32; Schindel 2019, p. 10). These drainage basins include the Nueces River/West Nueces River, Frio River/Dry Frio River, Sabinal River, and Medina River Basins (Fratesi et al. 2015, pp. 10–13; Liu et al. 2017, p. 17).

Like other karst aquifers, water levels of the Edwards Aquifer are dynamic and fluctuate dramatically with recharge (i.e., distribution, amount, and intensity of rainfall) and discharge (i.e., well or springs) [Petitt and George 1956, p. 49; Buszka 1987, pp. 24–27; Maclay 1995, pp. 48, 52; Worthington et al. 2003, p. 4; Lindgren et al. 2004, pp. 40–41, 45]. Prolonged dry periods result in declines in aquifer water levels but rebound rapidly with return of precipitation (Petitt and George 1956, p. 49; Arnow 1959, pp. 27–29). Since records have been maintained, discharge of groundwater from the aquifer has exceeded recharge multiple times with water levels rebounding with increased rainfall (Petitt and George 1956, p. 49). The longest such period was the drought of record from the late 1940s to mid-1950s (Arnow 1959, pp. 27–29). Groundwater discharge exceeded recharge during several more bouts of drought in the remainder of the 20th century and into the 2000s (Buszka 1987, pp. 24–27; Maclay 1995, pp. 40, 43; Mace 2019, pp. 208, 210). Based on data for the Edwards Aquifer in Uvalde, Medina, and Bexar counties, discharge exceeded recharge 30 times between 1934 and 2020. The longest continuous period of reduced recharge was 1950 to 1956.

Groundwater pumping to meet municipal, industrial, and irrigation uses is a widely recognized threat to the persistence of subsurface and surface groundwater-dependent ecosystems (Danielopol et al. 2003, pp. 109–112; Eamus et al. 2016, pp. 317, 333–335; Mammola et al. 2019, pp. 645–646). Removal of groundwater from an aquifer leads to some degree of water level decline, especially if discharge of groundwater significantly exceeds recharge (Theis 1940, pp. 278–280; Alley et al. 2002, pp. 1986; Foster and Chilton 2003, pp. 1961–1962). Declining aquifer levels can result in spring flow decline or failure, loss of stream and creek base-flow, and/or drying of water-filled caverns (Springer and Stevens 2009, pp. 9–10; Eamus et al. 316–318, 333–335). If the groundwater decline is significant enough, it could result in changes to water levels in the aquifer that may affect the mimic cavesnail.

Climate Change

Anthropogenic climate change has the potential to impact groundwater quantity in the San Antonio segment (Green et al. 2011, pp. 538–546; Kløve et al. 2014, pp. 252–253, 258; U.S. Global Climate Change Research Program 2017, p. 14; Wineland et al. 2022, pp. 8–10). The

Edwards Aquifer is considered among Texas' most vulnerable aquifers to climate change due to its dependence on precipitation for recharge and very rapid response to decreased or increased recharge (Loáiciga et al. 2000, pp. 192–193; Mace and Wade 2008, pp. 658, 662, 664–665; Loáiciga and Schofield 2019, p. 236; Ding and McCarl 2020, p. 11). Reduced precipitation during dry periods is known to result in lower water levels in the Edwards Aquifer (Arnow 1959, pp. 21–24, 27–29). Changing climatic conditions, coupled with groundwater pumping, could lead to greater declines in aquifer water levels (Arnow 1959, pp. 21–24; Buszka 1987, pp. 24–27; Lindgren et al. 2004, p. 40).

Downscaled climate projections for Bexar County were obtained from the U.S. Climate Resilience Toolkit (U.S. Federal Government 2021, unpaginated). From 2023 to 2099, projections indicate that average daily maximum temperature will increase in that county from 28.3 °C (83 °F) in 2023 to 30 °C (86 °F) by 2099 under both high (Representative Concentration Pathway [RCP] 8.5) and low emissions (RCP 4.5). The average daily minimum temperature is projected to increase from 14.9 °C (58.9 °F) in 2023 to 19.2 °C (66.5 °F) in 2099 with high emissions and from 14.9 °C (58.9 °F) in 2023 to 16.7 °C (62 °F) under low emissions. Number of days per year above 40.5 °C (105 °F) in Bexar County are projected to increase from 2.3 days in 2023 to 52 days in 2099 with high emissions and from 4 days in 2023 to 13 days under low emissions. Average annual precipitation is not projected to change as markedly under high or low emission scenarios. With little change in rainfall and increasing temperatures, evapotranspiration would increase, reducing surface run-off and ultimately aquifer recharge (Chen et al. 2001, p. 398). During drought years, recharge could be reduced by 21-33% (Chen et al. 2001, p. 399). Flows at Comal Springs could decrease by 10%-24% which would initiate groundwater withdrawal reductions under current regulations (Chen et al. 2001, pp. 403-404).

Accompanying higher temperatures is the potential for more frequent drought and increasing aridity for Texas (Seager et al. 2007, pp. 1181, 1183; National Oceanic and Atmospheric Administration 2016, p. 3; Park et al. 2017, pp. 71–72; Wendt et al. 2018, p. 587; Marvel et al. 2019, p. 64). Severe droughts in Texas are now much more prevalent than they were 50 years ago (Rupp et al. 2012, pp. 1053–1054). Several prolonged droughts have been documented across central Texas since 1895 with the longest (i.e., drought of record) occurring from 1951 to 1956. In 2011, Texas experienced the worst annual drought since record-keeping began in 1895 (National Oceanic and Atmospheric Administration 2012, p. 4; Nielsen-Gammon 2012, pp. 61–94).

The region of the aquifer inhabited by the mimic cavesnail is an area typified by extensive faulting, large, cavernous openings, and a great capacity to store and transmit groundwater (Arnow 1959, p. 28). Wells in this area have historically discharged large volumes of water but evidenced relatively small declines in water level (Arnow 1959, p. 28). Water levels of the San Antonio segment did not experience decline during the 20th and early 21st centuries despite decades of use and multiple instances of drought (Maclay 1995, pp. 48, 52; Lindgren et al. 2004, 40–41, 45). If management of the San Antonio segment continues, we would expect that aquifer levels would not decline and cavesnail habitat would be maintained.

Groundwater Contamination

Karst aquifers are vulnerable to contamination given the high porosity and permeability of those systems, which can rapidly transport groundwater over long distances (Kaçaroğlu 1999, pp. 340–343; Clark 2000, pp. 1–2; Vesper et al. 2003, pp. 1–2; Bichuette and Trajano 2010, pp. 68–70; Opsahl et al. 2018, p. 3; Mahler and Musgrove 2019, pp. 245–246; Guerra and Debbage 2021, p. 2). Surface water (e.g., precipitation, run-off, and streamflow) recharging karst aquifers is often focused to specific entry points (e.g., caves, fractures, and sinkholes) that provide little opportunity for filtration of dissolved and solid materials (Leibundgut 1998, pp. 46–47, 59; Kaçaroğlu 1999, pp. 337–338, 340–342, 344–345).

Anthropogenic contaminants can be introduced to aquifers in a number of ways including 1) leaks from landfills, pipelines, petroleum storage tanks, septic tanks, and sewer lines, 2) spills of hazardous materials along roadways or railways and from petroleum extraction activities, 3) releases of untreated wastewater, and 4) land surface run-off from agricultural fields, impervious cover, and livestock operations (Vesper et al. 2003, p. 2; Johnson et al. 2009, pp. 44; Burri et al. 2019, pp. 142–145). Abandoned water and petroleum wells that intersect aquifer formations represent another potential source of groundwater contamination. Contamination events may be acute, occurring over a few hours or days, or chronic, taking place over years to decades (Proudlove 2001, pp. 202–203; Niemiller et al. 2013, pp. 1813–1814).

Major human activities that generate contaminants are agriculture (e.g., animal waste, fertilizers, herbicides, and pesticides), industry (e.g., hydrocarbons), and waste management (e.g., septic tanks and sewage) [Vesper et al. 2003, pp. 2–10; Burri et al. 2019, pp. 142–145; Li et al. 2021, pp. 2–4]. Common inorganic contaminants are various forms of nitrogen (e.g., ammonia, nitrate and nitrite), phosphorus, and heavy metals (e.g., zinc, mercury, and cadmium) (Burri et al. 2019, pp. 144–145; Li et al. 2021, p. 3). There are also hundreds of organic materials that can contaminate groundwater such as atrazine, benzene, chloroform, tetrachloroethene, and trichloroethene (Burri et al. 2019, pp. 144–146; Li et al. 2021, p. 3).

Given the San Antonio segment's status as a sole-source aquifer, substantial research and monitoring has been conducted on the aquifer's groundwater quality. Water quality investigations in the 1970s from two wells that produced the mimic cavesnail indicates that groundwater where cavesnails occur is neutral to slightly alkaline (i.e., >7 pH), relatively consistent in temperature (i.e., 28°C [82°F]), and of good quality with lower amounts of dissolved inorganic solids (e.g., specific conductivity, an indirect measure of the collective concentration of dissolved ions in solution) (Karnei 1978, pp. 115-116). Contaminants of potential concern include nitrate and organic materials such as atrazine, chloroform, and trichloroethene (Fahlquist and Ardis 2004, pp. 7–8; Johnson et al. 2009, pp. 23–26, 31–35, 45–

47; Musgrove et al. 2014, pp. 69–71). Such contaminants are most frequently associated with urban and suburban land-uses including residential and commercial development, industrial, transportation infrastructure, and waste disposal land uses (Wilson 2011, pp. 1–2; Lin and Gong 2016, pp. 384–385; Opsahl et al. 2018, p. 58).

Surface aquatic crustaceans (e.g., amphipods) and gastropods (i.e., *Tryonia*) display sensitivity to water quality (e.g., dissolved oxygen, pH, specific conductivity, and temperature) and potentially require specific parameters to thrive (Malcom et al. 2005, pp. 75–76; Martinez and Thome 2006, p. 14; Tsai et al. 2007, pp. 216–217; Pârvulescu and Hamchevici 2010, pp. 163–166; Martinez and Rogowski 2011, pp. 220–221). The introduction of contaminants (e.g., metals, pesticides, and polycyclic aromatic hydrocarbons) into aquatic systems can have sub-lethal (e.g., decreased growth and/or reproduction) to lethal impacts on aquatic snail populations (Nebeker and Puglisi 1974, p. 727; Borgmann et al. 1989, pp. 760–761; Muliss et al. 1996, pp. 211–212; Lysne et al. 2008, p.466; Wells et al. 2012, pp. 74; Chen et al. 2021, pp. 12–13).

The mimic cavesnail has not been studied regarding its response to types and amounts of inorganic or organic contaminants. It is unlikely that this snail is immune from the lethal or sublethal effects of groundwater contaminants. We would expect that the mimic cavesnail would respond to acute and chronic groundwater contamination events in a similar fashion as documented for other stygobiont invertebrates.

At deep aquifer levels, groundwater contamination is not historically widespread, is less prevalent, and at relatively lower concentrations than at shallower aquifer depths (Musgrove et al. (2014, pp. 69–70; Opsahl et al. (2018, p. 58). Groundwater contamination does not appear to have been a widespread or prevalent stressor for the species. The mimic cavesnail inhabits a deep portion of the San Antonio segment that is characterized by older groundwater less affected by contaminants.

Conservation Measures and Existing Regulatory Mechanisms

Groundwater pumping from the San Antonio segment was not regulated until the late 1990s, just over 100 hundred years after the first artesian wells were drilled in Bexar County (Mace 2019, p. 208). Texas is the only U.S. state that applies the principle of absolute ownership, or rule of capture, to groundwater (Foster 2009, pp. 382–383; Burchi 2018, p. 120). In Texas, the rule of capture enables private landowners, in the absence of trespassing, negligence, malice, or willful waste, to withdraw unlimited amounts of groundwater from their property (Todd 1992, pp. 249–255; Kaiser and Skillern 2001, pp. 263–264; Opiela 2002, pp. 97–105; Cook et al. 2015, p. 50; Eoh 2015, pp. 1233–1236; Welles 2015, pp. 486–491; Closas and Molle 2018, p. 513). The

State’s groundwater receives some degree of local regulation through the formation and administration of groundwater conservation districts.

Groundwater conservation districts are the State of Texas’ preferred instrument for groundwater management (Lehman 2004, pp. 103–104, 107–109; Freese and Nichols, Inc. and LBG-Guyton Associates 2016, pp. 3-2–3-3). A groundwater conservation district is a voluntarily established legal entity, authorized by the Texas Legislature, to protect and manage groundwater resources within their jurisdiction (Welles 2015, pp. 491–494; Closas and Molle 2018, p. 513). Districts can regulate groundwater withdrawals through permitting of groundwater wells, reporting of groundwater production, and limits on withdrawals (Fipps 1998, pp. 4–7; Closas and Molle 2018, pp. 513–515). The Edwards Underground Water District, covering Bexar, Comal, Hays, Medina, and Uvalde counties, was formed in 1959 for the purpose of conserving and protecting groundwater in those areas (Gulley 2015, p. 12).

In the early 1990s, federal litigation (i.e., Sierra Club vs. Secretary of the Interior [No. MO-91-CA-069] United States District Court for the Western District of Texas) directed the Service to make determinations regarding minimum spring flows and aquifer levels necessary to support listed species occurring in the Comal and San Marcos Spring Systems. The Service produced a recovery plan with that guidance in 1996 (Service 1996, entire). Another outcome of this litigation was the creation of the Edwards Aquifer Authority in 1993 by the State of Texas to manage groundwater withdrawals (i.e., by nonexempt wells) from the San Antonio segment (National Research Council 2015, pp. 24–26; Hardberger 2019, pp. 193–194; Payne et al. 2019, p. 199). The regulatory area of the Edwards Aquifer Authority includes all or a portion of Bexar, Comal, Hays, Medina, and Uvalde counties.

The Edwards Aquifer Authority developed a habitat conservation plan, approved by the Service in 2013, that provides measures to minimize and mitigate take of the nine listed species related to covered activities (National Research Council 2015, pp. 27, 29, 32–36; RECON Environmental, Inc. 2021, pp. 3-55–3-67). Permittees to the plan include the Edwards Aquifer Authority, City of San Antonio acting through the San Antonio Water System, City of New Braunfels, City of San Marcos, and Texas State University (National Research Council 2015, pp. 25–26). Covered activities include groundwater withdrawals for drinking water supplies and irrigation as well as recreational activities (National Research Council 2015, pp. 32–36; RECON Environmental, Inc. 2021, pp. 2-1–2-16).

The voluntary minimization and mitigation measures of the plan are based on maintaining sufficient minimum flows at Comal and San Marcos Springs to sustain listed species during a reoccurrence of prolonged drought conditions (National Research Council 2015, pp. 32–36; National Academies of Science, Engineering, and Medicine 2018, pp. 67–68). The baseline for drought is Texas’ drought of record, when aquifer recharge was at its lowest recorded level (ICF 2022, p. 6). There are four primary spring protection measures in the habitat conservation plan

(National Research Council 2015, pp. 32–36; National Academies of Science, Engineering, and Medicine 2018, pp. 19-20; RECON Environmental, Inc. pp. 5-1–5-10, 5-38–5-41):

- Critical Period Management Stage V: Tiered reductions in groundwater withdrawals when Comal and San Marcos Springs flow or water levels at reference wells (i.e., J-17 and J-27) fall below certain volumes.
- Regional Water Conservation Program: Municipal conservation programs to reduce usage of groundwater.
- Voluntary Irrigation Suspension Program: Suspends use of Edwards Aquifer for irrigation during drought periods when reference wells reach specific water levels.
- Aquifer Storage and Recovery: Storage of excess permitted Edwards Aquifer in the Carrizo Aquifer.

During the severe drought conditions from 2014 to 2015, protections from the habitat conservation plan were implemented (both the Critical Period Management Stage V and the Voluntary Irrigation Suspension Program), and spring flows consequently remained above thresholds during that period (National Academies of Science, Engineering, and Medicine 2018, pp. 98–100). A review of the Edwards Aquifer Habitat Conservation Plan also suggests that flow protection measures, including groundwater modeling efforts, appear to be effective in meeting flow requirements of covered species (National Academies of Science, Engineering, and Medicine 2018, pp. 7–8, 109, 152). Additionally, the volume of groundwater pumped from the San Antonio segment have decreased since 2008, further lessening the impacts of drought on the Edwards Aquifer.

The Edwards Aquifer Recovery Implementation Program chose not to include the mimic cavesnail in the habitat conservation plan (RECON Environmental, Inc., p. 1–9). Rationale for not including the species in the plan was that the plan's actions are most applicable to spring-dwelling species that inhabit upper portions of the Edwards Aquifer (RECON Environmental, Inc., p. 1–9). However, protection of sustained flow at Comal and San Marcos Springs Systems does provide overarching protection for species that inhabit deep portions of the San Antonio segment. Persistence of surface discharge at those spring systems suggest that deeper levels of the aquifer have not been appreciably reduced and remains saturated with water.

Additional conservation measures include land protection efforts by the City of San Antonio's Edwards Aquifer Protection Program (Stone and Schindel 2002, pp. 38–39; Carnett 2022, unpaginated). In 2000, the voters of San Antonio passed Proposition 3, a $65 million sales tax initiative, to fund the acquisition (i.e., fee-simple and conservation easements) of open space to protect the contributing and recharge zones of the aquifer in Bexar County (Romero 2018, p. 2). That program was re-approved in 2005, 2010, and 2015 with additional funds to acquire open space (Reilly and Carter 2018, pp. 1-3–1-5). The effort was later expanded to acquire lands in Medina and Uvalde counties that contain larger portions of the contributing and recharge zones (Romero 2018, pp. 5–6, 8). The dedicated sales tax expired in 2021 with 97,124 ha (240,000 ac) acquired under the Edwards Aquifer Protection Program (Carnett 2022, unpaginated). The City of San Antonio recently approved an alternative funding stream to support land acquisitions through the commitment of $100 million over ten years (Carnett 2022, unpaginated).

Protection of open space has the potential to reduce the impacts of development (e.g., run-off from impervious cover, fertilizer applications, and wastewater), buffer against impacts of climate change, and maintain aquifer recharge (Reilly and Carter 2018, pp. 3-2, 3-6; Romero 2018, pp. 5–6). A land-use analysis was conducted for the San Antonio segment's contributing and recharge zones in Bexar, Comal, Hays, Travis, and Williamson counties (Guerra and Debbage 2021, entire). By 2001, 30% of the recharge zone in Bexar County had been urbanized with development growing through 2006 (Guerra and Debbage 2021, pp. 4–5). After 2006, the rate of urbanization decreased due to measures to protect sensitive surface areas of the aquifer (Guerra and Debbage 2021, pp. 5–6). Although no research has evaluated how land protection efforts have affected contaminant loads, there is some potential that risk has been reduced over the contributing and recharge zones.

Several other entities also have measures to protect groundwater from contamination including the Edwards Aquifer Authority's Aboveground Storage Tank Program, Agricultural Secondary Containment Assistance Program, and Abandoned Well Program among others (Edwards Aquifer Authority 2022, unpaginated). The San Antonio Water System implements several water quality protection measures including development regulations (i.e., Aquifer Quality Protection Ordinance No. 81491) for properties over the contributing and recharge zones, review of building permits and master development plans, regulation of underground storage tanks, commercial/industrial compliance, and an abandoned well program (San Antonio Water System 2022, unpaginated).

The conservation actions being undertaken in the Edwards Aquifer region have the potential to minimize groundwater reduction and contamination, both of which are potential stressors to the mimic cavesnail.

<u>Cumulative Effects</u>

We note that, by using the SSA framework to guide our analysis of the scientific information documented in the SSA report, we have analyzed the cumulative effects of identified threats and conservation actions on the species. To assess the current and future condition of the species, we evaluate the effects of all the relevant factors that may be influencing the species, including threats and conservation efforts. Because the SSA framework considers not just the presence of the factors, but to what degree they collectively influence risk to the entire species, our assessment integrates the cumulative effects of the factors and replaces a standalone cumulative-effects analysis.

ANALYSIS

To assess the current and future conditions of the mimic cavesnail, we established analysis units at well sites with documented records of the species. Units do not define populations but rather geographic areas we presume are areas of potential occupancy and/or areas important to or that could influence species survival. Delineation of analysis units was informed by the following variables:

- Regional groundwater flow patterns of the San Antonio Pool from Groschen (1996, pp. 26–27) and Lambert et al. (2010, p. 3)
- Inferred groundwater conduits from Worthington et al. (2003, p. 32) and Lindgren et al. (2004, p. 20). A 1 km (0.6 mi) buffer was applied to conduits in ArcGIS to account for locational uncertainty.
- Areas of high hydraulic conductivity in the artesian zone of the San Antonio Pool from Lindgren et al. (2004, p. 26).
- Proximity to the freshwater/saline-water interface

We defined immediate area analysis units at each well with the well as the center point. These units were established in ArcGIS by applying a 1 km (0.6 mi) radial buffer at each well. If the respective buffers of units intersected, they were grouped into a single analysis unit.

The 1 km (0.6 mi) distance encompasses an area of high hydraulic conductivity (Lindgren et al. 2004, p. 26) and includes inferred northeast trending groundwater conduits (Worthington et al. 2003, p. 32; Lindgren et al. 2004, p. 20). We assume this area is potentially important to or could influence the species' survival as it is an area of high permeability and concentrated groundwater flow. Analysis units were clipped to the southeastern extent of the artesian zone of the Edwards Aquifer. Mimic cavesnail habitat is unlikely to occur beyond that area given much lower permeability and lack of cavernous openings southeast of the freshwater/saline-water interface (Maclay and Small 1986, pp. 35, 67; Maclay 1995, pp. 26–27, 32).

It is likely that cavesnail habitat is not just restricted to the immediate area surrounding wells that have produced the species. The mimic cavesnail may inhabit a more spatially extensive and contiguous subterranean system of voids as has been evidenced for other stygobionts (Moss and Aley 2003, pp. 70–72; Buhay and Crandall 2005, pp. 4,264; Hart 2016, pp. 32, 34, 36–37; Beeman et al. 2013, pp. 379–380; Gorički et al. 2017, p. 7; Zakšek and Trontelj 2017 pp. 33–34; Vörös et al. 2018, p. 217). To assess stressors to the mimic cavesnail in areas between and surrounding immediate area analysis units, we created a larger analysis unit that encompassed those units, referred to as the potential area of occurrence. Information on the historical flow rate of wells in the immediate area analysis units and potential area of occurrence is very limited to nonexistent, based on a review of Texas Water Development Board (2022a, unpaginated) data. Data from the Edwards Aquifer Authority (2021, unpaginated) provides annual discharged volumes for 14 wells in our analysis units between 2010 to 2017. How much and at what rate these wells pumped groundwater prior to aquifer regulation is unknown.

CURRENT CONDITION

The most direct anthropogenic agent of mortality for the mimic cavesnail is expulsion from the deep aquifer through groundwater wells. The likely benthic lifestyle of this snail may make live individuals less susceptible to capture and expulsion by groundwater wells. There is recent evidence of the species' continued persistence at one operating groundwater well. The other two wells where cavesnails were found previously are capped and no longer extract water, though we assume the species still occurs in water-bearing strata below those sites. The mimic cavesnail's range may also be larger than currently known given that additional wells have never been sampled for the species due to lack of access.

Available evidence suggests that groundwater quantity to support habitat for the mimic cavesnail has not experienced changes from historical conditions. Management of groundwater withdrawals from the San Antonio segment has been in place since the late 1990s and pumped volumes have decreased since 2008. Aquifer water levels where mimic cavesnails reside also show no evidence of long-term decline, even at times of prolonged drought and unregulated pumping (Maclay 1995, p. pp. 48, 52; Lindgren et al. 2004, 40–41, 45). Flow protection measures are in place that principally protect Comal and San Marcos Spring Systems, but those measures would also benefit water levels deeper in the aquifer.

Based on available information, we expect that resiliency of the mimic cavesnail's population has not significantly degraded due to groundwater well mortality, reductions in groundwater quantity, or groundwater contamination. Although the species has naturally limited redundancy (i.e., three surface wells connecting to one contiguous subterranean population) and representation (i.e., adaptability) due to its small range, the best available information does not suggest that the species' redundancy and representation have changed from historical conditions.

FUTURE CONDITION

To assess the future conditions of the mimic cavesnail, we do not provide multiple potential scenarios. Instead, we analyzed the most plausible future projections for the threats of human population growth, groundwater demands, and climate change and assessed their effects on the species. These variables all have some potential to impact the cavesnail and its habitat into the future. The timescale for our future scenario is from 2022 to 2100, the maximum extent of climate change and land-use projections. Down-scaled climate change projections were obtained for Bexar County the U.S. Climate Resilience Toolkit's Climate Explorer (U.S. Federal

Government 2021, unpaginated). Human population growth projections for the San Antonio-New Braunfels Metropolitan Area and Bexar County were retrieved from the Texas Demographic Center (Texas Demographic Center 2022, unpaginated).

For projected land-use changes, we used the U.S. Environmental Protection Agency's (2019, unpaginated) Integrated Climate and Land-Use Scenarios which project to 2100. With those projections, we applied Shared Socioeconomic Pathway 5 (SSP5), a metric that predicts a faster rate of human population growth and land conversion (U.S. Environmental Protection Agency 2016, pp. 34–35, 46). A faster rate of human population growth is consistent with Texas Demographic Center population projections for Bexar County and the San Antonio-New Braunfels Metropolitan Area (Texas Demographic Center 2022, unpaginated). The Texas Water Development Board's (2022b, unpaginated) State Water Plan provides water demand projections through 2070.

Two of the three wells that produced mimic cavesnails are inactive which removes those as sources of mortality for the species. No new wells have been drilled in the immediate area analysis unit since 1995. For future conditions, we assume this trend will continue and be accompanied by an increase in the capping or plugging of older groundwater wells. Thus, we expect well mortality to decline to 2100.

The projected future of Bexar County, San Antonio-New Braunfels Metropolitan Area, and several counties in the aquifer's contributing and recharge zones includes increased human population growth and exurban and suburban development, demands for more water, and a warming, more drought-prone climate. The human population of Bexar County is predicted to increase from 2,214,963 in 2022 to 3,353,060 in 2050 (Texas Demographic Center 2022, unpaginated). The San Antonio-New Braunfels Metropolitan Area human population is projected to increase from 2,741,008 in 2022 to 4,467,980 in 2050 (Texas Demographic Center 2022, unpaginated). This growing human population will require additional water, either from groundwater or surface water resources. The Texas Water Development Board's Texas State Water Plan (2022b, unpaginated) projects that Bexar County's water needs will increase from 457,458,942 m^3 (370,868 ac-ft) per decade in the 2030s to 581,336,290 m^3 (471,297 ac-ft) per decade in the 2070s. Based on estimated existing supplies, potential shortages are expected over that 50-year period (Black & Veatch 2021a, pp. ES-7, ES-10; Black & Veatch 2021b, 5.3-8–5.3-9; Texas Water Development Board 2022b, unpaginated). To meet future water shortfalls, the South Central Texas Regional Water Planning Group has identified over 30 recommended water management strategies (e.g., water conservation, new ground and surface water supplies, and reuse) to conserve or identify new water resources (Black & Veatch 2021a, pp. ES-10–ES-15; Black & Veatch 2021b, pp. 5.2 1-1–5.2 33-23). The San Antonio Water System supplies water to nearly two million people in central Texas area and is the largest water supplier in Bexar County (Back & Veatch 2021a, p. 1–23). That public utility is moving towards a diversified water supply with less dependence on the Edwards Aquifer through a variety of initiatives (e.g., aquifer recovery and storage, desalination, and water conservation) (San Antonio Water System 2017, pp. 4–12, 20–25, 28–38, 42–45, 51–54). In 2017, the share of groundwater delivered to water-users dropped from 70% to 42% (drought year)/60% (average year) [Romero 2018, p. 14]. The San Antonio Water System projects those shares will be 31% (drought year)/52% (average year) by 2070 (Romero 2018, p. 14).

In addition to population growth and increased water needs, we considered the effects of climate change (National Oceanic and Atmospheric Administration 2016, pp. 1, 3; Kloesel et al. 2018, pp. 990, 995–996). Under low (RCP 4.5) and high (RCP 8.5) emissions, average daily maximum temperatures are projected to increase by 2–5 °C (3–9 °F) through 2099. Number of days with extreme temperatures (i.e., >41°C [>105°F]) will increase by 9 to 50 days. No substantial change in precipitation is expected to occur under either emission scenario. With increased temperatures and little change in rainfall, evapotranspiration could increase, reducing surface run-off and ultimately aquifer recharge (Chen et al. 2001, p. 398). During drought years, recharge could be reduced by 21–33% (Chen et al. 2001, p. 399). Flows at Comal Springs could decrease by 10%–24% which would initiate groundwater withdrawal reductions under current regulations (Chen et al. 2001, pp. 403–404).

Climate change may result in less groundwater extraction from the Edwards Aquifer given existing regulations to protect federally listed species in the Comal and San Marcos Springs Systems (Mace 2019, p. 212). We would also expect less dependence on groundwater in the future due to ongoing and planned efforts to conserve and augment water resources in the San Antonio-New Braunfels Metropolitan Area and Bexar County (San Antonio Water System 2017, pp. 4–12, 20–25, 28–38, 42–45, 51–54; Black & Veatch 2021a, pp. ES-10–ES-15; Black & Veatch 2021b, pp. 5.2 1-1–5.2 33-23). Regulatory mechanisms to maintain springflows, coupled with pivots to additional water sources to meet human needs, will aid in the maintenance of aquifer levels and persistence of mimic cavesnail habitat.

The region of the aquifer inhabited by the mimic cavesnail is an area typified by extensive faulting, large, cavernous openings, and a great capacity to store and transmit groundwater (Arnow 1959, p. 28). Wells in this area have historically discharged large volumes of water but evidenced relatively small declines in water level (Arnow 1959, p. 28). Water levels of the San Antonio segment did not experience decline during the 20th and early 21st centuries despite decades of use and multiple instances of drought (Maclay 1995, pp. 48, 52; Lindgren et al. 2004, 40–41, 45). If management of the San Antonio segment continues, we would expect that aquifer levels would not decline and cavesnail habitat would be maintained.

The potential for groundwater contamination in the San Antonio segment will continue into the future. Under a high human population growth scenario, land use projections suggest that large areas west and north of Bexar County will be converted to low and high density exurban, suburban, and urban developments by 2100 (U.S. Environmental Protection Agency 2019, unpaginated). Much of the exurban and suburban development is expected to occur outside of municipal boundaries in unincorporated areas of counties where land use regulations (e.g., restrictions on impervious cover) are non-existent (Siglo Group 2022, pp. 13–14). Run-off from existing and expanded impervious cover in sensitive areas of the aquifer could affect groundwater quality over time. New contaminant sources are expected to be added to the region with increased human populations and expanded development; many existing contaminant sources will persist.

There is an ongoing effort by the City of San Antonio to protect sensitive areas of the contributing and recharge zones in Bexar, Medina, and Uvalde counties. Existing protected lands potentially aid in reducing transport of contaminants to the San Antonio segment

The mimic cavesnail is also somewhat buffered from the immediate effects of contaminants in the next 10-20 years because of the depth of the aquifer where the species occurs. Deeper portions of that aquifer segment have historically been less impacted by contaminants. However, that could change over several decades with increasing urbanization (Musgrove et al. 2019, p. 14). The San Antonio segment has a great capacity to assimilate and dilute contaminants due to the massive volumes of water transported through the aquifer (Johnson et al. 2009, p. 44). That assimilative capacity could be exceeded over decades of contaminant loading, eventually entering the deeper areas of the aquifer (Johnson et al. 2009, p. 58; Opsahl et al. 2018, p. 58). Even with water quality protection measures, we expect some level of contaminant loading will continue with concentrations increasing in deeper portions of the aquifer. We have no information to determine whether contaminants would ever reach concentrations that would impair cavesnail habitat.

Well mortality, groundwater quantity (including reductions via climate change), and groundwater quality are not expected to be significant stressors through 2100 for the mimic cavesnail based on the information in the models we assessed. If management of the San Antonio segment and efforts to diversify water supplies continue, we would not expect mimic cavesnail habitat to be reduced due to aquifer drawdown. Land use across the aquifer's contributing and recharge zones will intensify into the future which could impact groundwater quality; however, land protection measures may minimize contaminants loads. The assimilative capacity of the San Antonio segment and the depths at which the cavesnail occur may also limit the effects of contaminants. Contaminants in the deep aquifer will likely increase to some extent by the end of the 21st century. It is uncertain if concentrations would reach levels that would affect the mimic cavesnail. Based on the best available information, there is a low potential for effects to cavesnail habitat, such as reduction in groundwater quantity and quality, and well mortality is not expected to be a significant stressor. Therefore, we expect the mimic cavesnail will retain similar levels of resiliency, redundancy, and representations as it has currently.

FINDING

Regulatory Framework
Section 4 of the Act (16 U.S.C. 1533) and its implementing regulations (50 CFR part 424) set forth the procedures for determining whether a species is an "endangered species" or a "threatened species." The Act defines an endangered species as a species that is "in danger of extinction throughout all or a significant portion of its range," and a threatened species as a species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Act requires that we determine whether any species is an "endangered species" or a "threatened species" because of any one or a combination of the following factors:

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) The inadequacy of existing regulatory mechanisms; or
(E) Other natural or manmade factors affecting its continued existence.

These factors represent broad categories of natural or human-caused actions or conditions that could have an effect on a species' continued existence. In evaluating these actions and conditions, we look for those that may have a negative effect on individuals of the species, as well as other actions or conditions that may ameliorate any negative effects or may have positive effects.

The Act does not define the term "foreseeable future, which appears in the statutory definition of "threatened species." Our implementing regulations at 50 CFR 424.11(d), as revised in 2019, set forth a framework for evaluating the foreseeable future on a case-by-case basis. The term "foreseeable future" extends only so far into the future as we can reasonably determine that both the future threats and the species' responses to those threats are likely. In other words, the foreseeable future is the period of time in which we can make reliable predictions. "Reliable" does not mean "certain"; it means sufficient to provide a reasonable degree of confidence in the prediction. Thus, a prediction is reliable if it is reasonable to depend on it when making decisions.

It is not always possible or necessary to define the foreseeable future as a particular number of years. Analysis of the foreseeable future uses the best scientific and commercial data available and should consider the timeframes applicable to the relevant threats and to the species' likely responses to those threats in view of its life-history characteristics. Data that are typically relevant to assessing the species' biological response include species-specific factors such as lifespan, reproductive rates or productivity, certain behaviors, and other demographic factors.

Status Assessment

Status Throughout All of Its Range

After evaluating threats to the species and assessing the cumulative effect of the threats under the section 4(a)(1) factors, we found that the potential threats of well mortality, groundwater quantity, and groundwater contamination are not affecting the viability of the mimic cavesnail. Direct mortality through expulsion from groundwater wells (Factor E) is occurring, but the species' benthic lifestyle, high reproductive rate, and short lifespan result in this level of mortality being unlikely to affect the population's resiliency. Because it is a benthic species, it is less susceptible to entrainment and expulsion from wells, and species with life history traits like the mimic cavesnail's are unlikely to be affected by the mortality observed at the groundwater wells where it has been found. Further, groundwater quantity (Factor A) at the depths where mimic cavesnail occurs has not been affected by groundwater withdrawals, and the best available information does not indicate that will change in the future. Finally, we have no evidence of groundwater contamination (Factor A) at the depths where the mimic cavesnail occurs. The mimic cavesnail is expected to retain the redundancy, representation, and resiliency that it has known to have had in the past. Thus, after assessing the best available information, we conclude that the mimic cavesnail is not in danger of extinction throughout all of its range.

Therefore, we proceed with determining whether the mimic cavesnail is likely to become endangered within the foreseeable future throughout all of its range. The timescale for our future scenario is from 2022 to 2100, the maximum extent of climate change and land-use projections and species response. The projected future of Bexar County, San Antonio-New Braunfels Metropolitan Area, and several counties in the aquifer's contributing and recharge zones includes increases in human population and exurban and suburban development. This growing human population will require additional water, either from groundwater or surface water resources. Based on estimated existing supplies, potential shortages are expected (Black & Veatch 2021a, pp. ES-7, ES-10; Black & Veatch 2021b, 5.3-8–5.3-9; Texas Water Development Board 2022b, unpaginated). However, we would also expect less dependence on groundwater in the future due to ongoing and planned efforts to conserve and augment water resources in the San Antonio-New Braunfels Metropolitan Area and Bexar County (San Antonio Water System 2017, pp. 4–12, 20–25, 28–38, 42–45, 51–54; Black & Veatch 2021a, pp. ES-10–ES-15; Black & Veatch 2021b, pp. 5.2 1-1–5.2 33-23).

Accompanying population growth and increased water needs will be the effects of climate change (National Oceanic and Atmospheric Administration 2016, pp. 1, 3; Kloesel et al. 2018, pp. 990, 995–996). Under both high (RCP 8.5) and low (RCP 4.5) emissions, increased temperatures and little change in rainfall are projected. With these projected changes evapotranspiration could increase, reducing surface run-off and ultimately aquifer recharge (Chen et al. 2001, p. 398). During drought years, recharge could be reduced by 21–33% (Chen et al. 2001, p. 399). Flows at Comal Springs could decrease by 10%–24% which would initiate groundwater withdrawal reductions under current regulations (Chen et al. 2001, pp. 403–404).

Climate change will likely result in less groundwater extraction from the Edwards Aquifer given existing regulations to protect federally listed species in the Comal and San Marcos Springs Systems (Mace 2019, p. 212). We would also expect less dependence on groundwater in the future due to ongoing and planned efforts to conserve and augment water resources in the San Antonio-New Braunfels Metropolitan Area and Bexar County (San Antonio Water System 2017, pp. 4–12, 20–25, 28–38, 42–45, 51–54; Black & Veatch 2021a, pp. ES-10–ES-15; Black & Veatch 2021b, pp. 5.2 1-1–5.2 33-23). Regulatory mechanisms to maintain springflows, coupled with pivots to additional water sources to meet human needs, will aid in the maintenance of aquifer levels and persistence of mimic cavesnail habitat.

Wells in the region of the aquifer inhabited by the mimic cavesnail have historically discharged large volumes of water but evidenced relatively small declines in water level (Arnow 1959, p. 28). Water levels of the San Antonio segment did not experience decline during the 20th and early 21st centuries despite decades of use and multiple instances of drought (Maclay 1995, pp. 48, 52; Lindgren et al. 2004, 40–41, 45). If management of the San Antonio segment continues, we would expect that aquifer levels would not decline and mimic cavesnail habitat would be maintained.

The potential for groundwater contamination in the San Antonio segment will continue into the future, particularly under a high human population growth scenario, with large areas west and north of Bexar County converted to low and high density exurban, suburban, and urban developments by 2100 (U.S. Environmental Protection Agency 2019, unpaginated). Run-off from existing and expanded impervious cover in sensitive areas of the aquifer could affect groundwater quality over time. New contaminant sources are expected to be added to the region with increased human populations and expanded development; many existing contaminant sources will persist, although because of the depth of the aquifer where the species occurs, the contaminants are unlikely to affect the mimic cavensail. There is an ongoing effort by the City of San Antonio to protect sensitive areas of the contributing and recharge zones in Bexar, Medina, and Uvalde counties. Existing and future protected lands will potentially aid in reducing transport of contaminants to the San Antonio segment, thus potentially buffering the mimic cavesnail from the immediate effects of contaminants. Deeper portions of that aquifer segment have historically been less impacted by contaminants, but that could change over several decades with increasing urbanization (Musgrove et al. 2019, p. 14).

Furthermore, the San Antonio segment has a great capacity to assimilate and dilute contaminants due to the massive volumes of water transported through the aquifer (Johnson et al. 2009, p. 44). However, even with water quality protection measures, we expect some level of contaminant loading will continue with concentrations increasing in deeper portions of the aquifer. We have no information to determine whether contaminants would ever reach concentrations that would impair mimic cavesnail habitat.

We expect that well mortality has declined and will continue to decline into 2100. Two of the three wells that produced mimic cavesnails are inactive which removes those as sources of mortality for the species. No new wells have been drilled in the immediate area analysis unit since 1995. For future conditions, we assume that this trend will continue and be accompanied by an increase in the capping or plugging of older groundwater wells.

After assessing the best available information, we find that well mortality, groundwater quantity (including reductions through climate change), and groundwater quality are not expected to be significant stressors through 2100 for the species, and we conclude that the mimic cavesnail is not likely to become endangered within the foreseeable future throughout all of its range.

Status Throughout a Significant Portion of Its Range

Under the Act and our implementing regulations, a species may warrant listing if it is in danger of extinction or likely to become so in the foreseeable future throughout all or a significant portion of its range. Having determined that the mimic cavesnail is not in danger of extinction or likely to become so in the foreseeable future throughout all of its range, we now consider whether it may be in danger of extinction or likely to become so in the foreseeable future in a significant portion of its range—that is, whether there is any portion of the species' range for which it is true that both (1) the portion is significant; and (2) the species is in danger of extinction now or likely to become so in the foreseeable future in that portion. Depending on the case, it might be more efficient for us to address the "significance" question or the "status" question first. We can choose to address either question first. Regardless of which question we address first, if we reach a negative answer with respect to the first question that we address, we do not need to evaluate the other question for that portion of the species' range.

We evaluated the range of the mimic cavesnail to determine if the species is in danger of extinction now or likely to become so in the foreseeable future in any portion of its range. The mimic cavesnail is a narrow endemic that functions as a single, contiguous population and occurs within a very small area; it is known from three groundwater wells in Bexar County, Texas. Thus, there is no biologically meaningful way to break this limited range into portions, and the threats that the species faces affect the species comparably throughout its entire range. As a result, there are no portions of the species' range where the species has a different biological status from its rangewide biological status. Therefore, we conclude that there are no portions of the species' range that warrant further consideration, and the species is not in danger of extinction or likely to become so in the foreseeable future in any significant portion of its range. This does not conflict with the courts' holdings in *Desert Survivors* v. *U.S. Department of the Interior*, 321 F. Supp. 3d 1011, 1070-74 (N.D. Cal. 2018), and *Center for Biological Diversity v.*

Jewell, 248 F. Supp. 3d. 946, 959 (D. Ariz. 2017) because, in reaching this conclusion, we did not apply the aspects of the Final Policy on Interpretation of the Phrase "Significant Portion of Its Range" in the Endangered Species Act's Definitions of "Endangered Species" and "Threatened Species" (79 FR 37578; July 1, 2014), including the definition of "significant" that those court decisions held to be invalid.

Determination of Status

Our review of the best available scientific and commercial information indicates that the mimic cavesnail does not meet the definition of an endangered species or a threatened species in accordance with sections 3(6) and 3(20) of the Act. Therefore, we find that listing the mimic cavesnail is not warranted at this time.

COORDINATION WITH STATES

We invited Texas Parks and Wildlife Department (TPWD) to participate in the SSA development. TPWD was also provided an opportunity to review the draft SSA, but we did not receive any comments on the report.

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