U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Planorbella magnifica*

COMMON NAME: Magnificent Ramshorn

LEAD REGION: Region 4 (Southeast Region)

DATE INFORMATION CURRENT AS OF: 06/10/2021

STATUS/ACTION

___ Species assessment - determined either we do not have sufficient information on threats or the information on the threats does not support a proposal to list the species and, therefore, it was not elevated to Candidate status

___ Listed species petitioned for uplisting for which we have made a warranted-but-precluded finding for uplisting (this is part of the annual resubmitted petition finding)

___ Candidate that received funding for a proposed listing determination; assessment not updated

___ New candidate

_X_ Continuing candidate

___ Listing priority number change
Former LPN: ___
New LPN: ___

___ Candidate removal: Former LPN: ___
- ___ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.
- ___U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.
- ___ F – Range is no longer a U.S. territory.
- ___ I – Insufficient information exists on biological vulnerability and threats to support listing.
- ___ M – Taxon mistakenly included in past notice of review.
- ___ N – Taxon does not meet the Act's definition of "species."
- ___ X – Taxon believed to be extinct.

Date when the species first became a Candidate (as currently defined): 10/26/2011

Petition Information:
___ Non-petitioned
_X_ Petitioned; Date petition received: 4/20/2010
90-day substantial finding FR publication date: 9/27/2011
12-month warranted but precluded finding FR publication date: 10/26/2011

FOR PETITIONED CANDIDATE SPECIES:
a. Is listing warranted (if yes, see summary of threats below)? Yes
b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? Yes
c. Why is listing precluded? Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. Due to Service and North Carolina Wildlife Resources Commission (NCWRC) conservation efforts (i.e. propagation and planned species reintroductions), the Service has completed a Species Status Assessment andrescheduled the status review of the Magnificent Ramshorn for fiscal year 2022..

ANIMAL/PLANT GROUP AND FAMILY: Snails – Pulmonata/Planorbidae

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: North Carolina (Brunswick and New Hanover Counties)

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE: North Carolina; the species is currently believed to be extirpated from the wild, but is being captively held and propagated.

LAND OWNERSHIP: The species is presumed extirpated in the wild. Presently the only known surviving individuals of the species are being held as captive populations – one established and maintained by a private individual at his residence in Pender County, North Carolina, one at NC State University's College of Veterinary Medicine's Aquatic Epidemiology Conservation Laboratory in Raleigh, North Carolina, and one at NCWRC's Conservation Aquaculture Center in Marion, North Carolina.

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LEAD FIELD OFFICE CONTACT: Raleigh NC Field Office; Pete Benjamin, 919-856-4520x11; pete_benjamin@fws.gov

BIOLOGICAL INFORMATION

Species Description

The following is adapted from Adams 1990a and 1993 and references therein: The Magnificent Ramshorn is a freshwater snail in the family Planorbidae (Pilsbry 1903), a family of air-breathing snails. It is the largest North American snail in this family. It has a discoidal (i.e., coiling in one plane), relatively thin shell that reaches a diameter commonly exceeding 35 millimeters (mm) (1.38 inches) and heights exceeding 20 mm (0.79 inch). The great width of its shell, in relation to the diameter, makes it easily identifiable at all ages. The shell is tan/brown colored and is thin and fragile. The body underneath the thin shell is a dark, maroon color and has leopard-like spots (I. Knox, pers. comm., email to S. McRae, 8/23/2019). The center of the shell is deeply sunken on each side, with coils having steep slopes which form acute to sub-acute angles on the outside edges of the coils. The aperture of the shell is somewhat bell-shaped and very wide, extending beyond the sides of the shell.

Taxonomy

The Magnificent Ramshorn was described by Pilsbry (1903) from the lower Cape Fear River region of North Carolina. Pilsbry (1903) placed it in the genus *Planorbis* Muller 1774. Baker (1945) reassigned the species to the genus *Helisoma* Swainson 1840. He recognized two subgenera under *Helisoma* – *Pierosoma* Dall 1905 and *Planorbella* Haldeman 1842 – and placed the Magnificent Ramshorn under *Pierosoma*. Taylor (1966) subsequently elevated *Planorbella* to full genus rank and placed the subgenus *Pierosoma* within it. The species' reproductive system (figured by Baker 1945: pl. 31, fig. 20), shell characters, and DNA sequence data all support *Planorbella magnifica* as a valid species (Bogan et al. 2003, pp. 5 and 6). The Service has reviewed the available taxonomic literature, and is not aware of any challenges to the validity of this species.

Background

The Magnificent Ramshorn is a southeastern North Carolina endemic species. The species is known from only four sites in the lower Cape Fear River Basin in North Carolina. Although the complete historical range of the species is unknown, the size of the species and the fact that it was not reported until 1903 is an indication that the species may have always been rare and

localized (Adams 1993, p. 2). Prior to 1992, the Magnificent Ramshorn had been recorded only from Greenfield Lake, a millpond located on a tributary to the Cape Fear River within the present city limits of Wilmington, New Hanover County, North Carolina (Bartsch 1908, pp. 697 and 698) and Orton Pond (also sometimes referred to as Sprunt's Pond), a millpond located on Orton Creek in Brunswick County, North Carolina (Adams and Gerberich 1988, p. 125; Adams 1990a, p. 27). During range-wide surveys in 1992 and 1993, Adams (1993, p. 4) recorded the species at one additional site, Sand Hill Creek Pond (also referred to as Pleasant Oaks Pond or Big Pond), a millpond on Sand Hill Creek in Brunswick County, North Carolina. In 2004, Andy Wood with the National Audubon Society discovered an additional small occurrence of the species in McKinzie Pond, a millpond on McKinzie Creek, in Brunswick County, North Carolina (Andy Wood, Wilmington, NC, pers. comm. 2004). Surveys of over a hundred potential sites over the last few decades have not uncovered any additional localities.

The Magnificent Ramshorn was last recorded in Greenfield Lake by Bartsch in 1908 (Adams and Gerberich 1988, p. 125; Adams 1990a, p. 27); it was last seen in Sand Hill Creek Pond in 1994 (Wood 2002, p. 9) and the last and only observation of the species in McKinzie Pond was in 2004 (Wood, pers. comm. 2008 and 2010). The species is now believed to be extirpated from these three localities. Adams and Gerberich (1988, p. 125) last observed a living specimen in Orton Pond in 1986. During a subsequent survey in 1987, they were able to find only shell material and reported that much of the aquatic vegetation had died back. Access to the Orton Pond has since been restricted by the landowner (Adams and Gerberich 1988, p. 125; William Adams, Wilmington, NC, pers. comm. 1990 and 2003; Wood pers. comm. 2009, 2015) and it is currently unknown if the species still survives in the pond.

In 1992, Mr. Andy Wood established a captive, refuge population of the Magnificent Ramshorn at the North Carolina Aquarium at Fort Fisher, North Carolina, under a captive propagation permit issued by the North Carolina Wildlife Resources Commission (NCWRC). Salt contamination of the aquaria in which the snails were held, believed to have been caused by salt-laden air circulating within the facility, subsequently forced Mr. Wood to establish holding facilities for the snail at his residence (Wood 2004, p. 9). Unless the species still survives in Orton Pond, which appears unlikely (see "Threats," section A. below) the snails being held and propagated by Mr. Wood, NC State University, and NCWRC are currently the only Magnificent Ramshorn snails known in existence.

Habitat/Life History

Although the Magnificent Ramshorn is a large snail, its shell is thin and fragile indicating that it is adapted to lentic (still or slow flowing) aquatic habitats (Bartsch 1908, p. 697; Adams 1993, pp. 2 and 3). Available information indicates that suitable habitat for the species is restricted to relatively shallow, sheltered portions of still or sluggish, freshwater bodies with an abundance and diversity of submerged and emergent aquatic vegetation and a circumneutral pH (pH within the range of 6.8 – 7.5) (Adams 1993, p. 8).

The pre-settlement distribution and habitat use of the species is not well understood. The only known records for the species are post-1900 and are from manmade millponds constructed in the 1700s to provide a freshwater source for rice agriculture (Adams 1993, pp. 21 and 22).

However, it is highly plausible that the species inhabited beaver ponds, which were plentiful in the region prior to the extirpation of the North American beaver (*Castor canadensis*) in North Carolina circa 1900 and subsequently persisted in millponds which replicated habitat conditions found in the beaver ponds and offered the only available suitable habitat (Adams 1993 and references therein, p. 22). It is also possible that the species may also have once been a faunal component of sluggish portions of the Cape Fear River proper until natural forces (e.g., sea level rise and changes in the inlet due to storm events) and/or navigational changes, which began as early as 1822, altered salinity regimes, flow and current patterns, and other hydrological conditions. These alterations would have made conditions unsuitable for the snail and limited it to portions of tributary streams providing suitable habitat protected from water quality and hydrological changes occurring elsewhere in the river basin (Adams 1993, pp. 21 and 22).

Bartsch (1908, p. 698) reported finding the Magnificent Ramshorn only in fragrant waterlily (*Nymphaea odorata*) and pondweed (*Potamogeton* sp.) beds in cove areas of Greenfield Lake. Adams and Gerberich (1988, p. 125), Adams (1993, p. 8), and Wood (2002, p. 1) also reported finding the species on aquatic vegetation, fragrant waterlily and spatterdock (*Nuphar lutem*), in similar sheltered habitat in Orton Pond, Sand Hill Creek Pond, and McKinzie Pond, respectively. However, Adams (1993, p. 8) reported that the species appeared to be more generally distributed in Sand Hill Creek Pond than what he observed in Orton Pond. Adams (1993, p. 8) reported that the maximum depth where he found the species in Orton Pond and Sand Hill Creek Pond was approximately one meter. The Planorbidae family of snails is on the whole a distinctly shallow-water group (Baker 1943, p. 17).

Salinity and pH also are major factors limiting the distribution of the Magnificent Ramshorn. Wood (2002, p. 3) reported that captive held Magnificent Ramshorn snails ceased all activity, withdrew into their shell, and sank to the bottom of their tank within 24 hours of exposure to salinity levels of 1.0 part per thousand (ppt). Within 8 hours they withdrew into their shell and died within 36 hours if not removed from water with a salinity of 5 ppt. Also, Wood (2002, pp. 2 and 3) observed that Magnificent Ramshorn snails fed and moved around normally in water with a pH of 6.8 to 7.5, but that the snails' feeding and other activity would cease altogether at pH levels at or below 6.5 and at or above 8.0; however, snails formerly at the Watha hatchery were kept at pH between 7.95 and 8.5 with no issues to health or activity (I. Knox, pers. comm., email to S. McRae, 8/23/2019). The NCWRC's 2020 research indicate a significant decline in Magnificent Ramshorn embryonic development at a pH of 5.0 and below (H. Lohmeyer, pers. comm., email to T. Augspurger, 6/10/2021). Greenfield Lake (NC Department of Environment and Natural Resources [NCDENR] 2004, p. 331), Orton Pond, Sand Hill Creek Pond (Adams 1993, App. C Field Data Sheets) and McKinzie Pond (Wood pers. comm. 2010) were all reported to have a circumneutral pH, i.e., within the range 6.8 – 7.5. This is higher than typical for many of the water bodies in the region. This is believed to be due to significant input of groundwater from underlying limestone formations in the watersheds of the creeks feeding these impoundments (Adams and Gerberich 1988, p. 125).

Like other species in the family Planorbidae, the Magnificent Ramshorn has the ability to breathe free air. Rather than having gills, the mantle cavity walls are heavily vascularized and form a lung sac (adapted from Baker 1945, p. 17). This gives the snails the ability to draw oxygen out

of the air, as well as breathe under water. However, the length of time the species can live out of water is unknown and likely depends on several factors such as air humidity levels and air temperature.

Members of the family Planorbidae are hermaphroditic (individuals have both male and female reproductive organs) (Baker 1943, p. 4). However, it is currently unknown whether they self–fertilize their eggs, mate with other individuals of the species, or both. Wood (2004, p. 12) reported that, while he has not precisely documented mating, he has observed pairs bonded to one another for more than 15 minutes. It is believed that in the wild the species reaches sexual maturity at two years of age; however, Wood (2004, p. 2) reported that in captivity, possibly due to a supplemental diet, the species can reach sexual maturity during the first year of age. The Magnificent Ramshorn lays fertilized eggs on the undersides of leaves of aquatic vegetation and shows a preference for spatterdock (Wood 2004, p. 12). In captivity the species has also been reported to lay eggs on any smooth, submerged material, including the sides of containers in which they are held (Wood 2004, p. 12). Wood (2004, p 12; 2010 p. 4) reported egg laying is likely triggered by water temperature and typically begins in April, with maximum egg production occurring during June and July, and likely extends as late as at least October. It is currently unknown how many egg masses can be produced by an individual snail. Typically egg masses typically contain 20 to 30 eggs and, depending on water temperature, eggs hatch within 16 to 25 days (Wood 2010, p. 4), although in 2011 some egg masses hatched within 14 days (Wood pers. comm. 2012). While juvenile Magnificent Ramshorns have eyes, the eyes gradually disappear as the snails grow and adults of the species are blind (Dall 1907, p. 90; Bartsch 1908, p. 698; Adams 1993, P. 18). Dall (1907, p. 90) reported that the life span of the Magnificent Ramshorn is likely about 2 years; Adams (1993, p. 18) reported that a study of growth rest lines on the shells of available specimens support this conclusion (the species' metabolism and growth slow down during the winter months, leaving growth rings similar to growth rings on trees).

Like other members of the Planorbidae family, the Magnificent Ramshorn is believed to be primarily vegetarian, feeding on submerged aquatic plants, algae, and detritus (decomposing plant material) (Baker 1943, p. 19; Wood 2004, p. 13). Wood (2004, p. 13) observed that the Magnificent Ramshorn showed a preference for spatterdock, especially the ripe seed head of the plant. In captivity, the species has also been reported to feed on Carolina fanwort (*Cabomba caroliniana*) (D. DuMond pers. comm. to Adams 1993), algae, detritus, lettuce, and commercial foods containing algae meal (Wood 2004, pp. 1, 7 and 13).

Historical Range/Distribution

The species has been recorded only from Greenfield Lake within the present city limits of Wilmington, New Hanover County, North Carolina (Bartsch 1908, pp. 697 and 698); as well as Orton Pond (Adams and Gerberich 1988, p. 125; Adams 1990a p. 27), Sand Hill Creek Pond (Adams 1993, p. 4) and McKinzie Pond, in Brunswick County, North Carolina (Wood pers. comm. 2004).

Current Range/Distribution

Available information indicates that the Magnificent Ramshorn is likely extirpated from the wild. Presently, the only known surviving individuals of the species are being held as part of captive populations; one established and maintained by a private individual at his residence in Pender County, North Carolina, one at NC State University's Aquatic Epidemiology Conservation Laboratory in Raleigh, North Carolina, and one at NCWRC's Conservation Aquaculture Center in Marion, North Carolina. There is no longer a population at the NCWRC's Watha State Fish Hatchery in Watha, North Carolina.

Population Estimates/Status

Currently known only from three established captive populations, one population currently comprised of approximately 775 adults, one with approximately 100 adults (at a facility for which covid-19 restrictions required temporarily scaled-back operations), and one with <100 adults; the Magnificent Ramshorn is highly vulnerable to extinction.

THREATS

A. The present or threatened destruction, modification, or curtailment of its habitat or range. Although the complete historical range of the Magnificent Ramshorn is unknown, available information indicates that the species was likely once an inhabitant of beaver ponds on tributaries in the lower Cape Fear River basin; the species may also have once inhabited backwater and other sluggish portions of the main channel of lower Cape Fear River (Adams 1993, pp 21-22). Beaver pond habitat was eliminated throughout much of the lower Cape Fear River as a result of the extirpation of the beaver due to trapping and hunting during the 19th and early 20th centuries. This, together with draining and destruction of beaver ponds for development, agriculture and other purposes, is believed to have led to a significant decline in the in the snails' habitat and significant reduction in its abundance (Wood 2010, pp. 6 and 7). Also, dredging and deepening of the Cape Fear River channel, which began as early as 1822, and opening of the Atlantic Intercoastal Waterway (through Snow's Cut) in 1930 for navigational purposes have caused saltwater intrusion, altered the diversity and abundance of aquatic vegetation, and changed flows and current patterns far up the river channel and its lower tributaries (Adams 1993, p 22; Wood 2010, p 7). Under these circumstances, the Magnificent Ramshorn could have survived only in areas of tributary streams not affected by salt water intrusion and other changes, such as the millponds protected from saltwater intrusion by their dams (Adams 1993, p. 22).

The extirpation of the Magnificent Ramshorn from Greenfield Lake is likely attributable to alteration of the lake's water quality and chemistry resulting from past events. These include breaks in sewerlines on the bottom of the lake; sewage overflow from nearby manholes during storm events; runoff of fertilizers, sediment, toxic chemicals, and other pollutants from the heavy development within the watershed; and/or, efforts by the city to control aquatic plants and algae within the lake (Adams 1990b, p. 104). As a result of heavy nutrient input, Greenfield Lake has become eutrophic and the majority of the aquatic vegetation currently present within the lake is filamentous green algae (Hackney and Brady 1996, p. 19; Adams pers. comm. 2003). Also, the city routinely conducted winter water-level drawdown in the past, in an attempt to control aquatic plant and algae levels within the lake. These drawdowns also likely had an adverse effect on the snail, as well the aquatic vegetation on which it is generally found (Adams 1990b,

p. 104).

The Sand Hill Creek population of the Magnificent Ramshorn is believed to have been extirpated in 1996 when the dam on the pond was breached during flooding associated with Hurricane Fran. Drawdown of the pond due to failure of the dam and saltwater intrusion into the pond affected both the Magnificent Ramshorn as well as the aquatic vegetation providing habitat for the snail, and researchers were unable to locate the snail during a subsequent survey (Wood pers. comm. 1996). This population of the species was last surveyed in 2007 and no evidence of the snail was found (Wood 2010, p. 2).

The Magnificent Ramshorn was last observed in McKinzie Pond in 2004 (Wood pers. comm. 2008). This population of the species is believed to have been extirpated due to saltwater intrusion resulting from prolong drought conditions. The reduction of freshwater levels feeding the stream allowed the tidal flow of saltwater to extend further up McKinzie Creek into the area harboring the snail (Wood pers. comm. 2008). Wood (2010, p. 2) reported that much of the submerged and emergent aquatic vegetation that previous flourished at this site, including spatterdock and cabomba, was damaged by saltwater.

Access to Orton Pond by researchers surveying for the Magnificent Ramshorn snail has been restricted since 1990 (Adams and Gerberich 1988, p. 125; Adams pers. comm. 1990 and 2003; Wood pers. comm. 2009). However, Adams (1993, p. 9) reported that nuisance aquatic vegetation growth was increasing significantly in the pond in the late 1980s, possibly due to increased nutrient supply in the headwater reaches of Orton Creek from golf course and other development activities in the Boiling Springs Lakes area. He also reported that the landowners unsuccessfully attempted to control the aquatic vegetation by a partial drawdown of the lake during the winter 1989/1990, a method extremely detrimental to species like the Magnificent Ramshorn. It is currently unknown whether the snail survived this drawdown or whether the owners made subsequent attempts to control aquatic vegetation in Orton Pond that may have eliminated the species.

The human residential population of Brunswick and New Hanover Counties is rapidly increasing – both counties are a popular vacationing and retirement areas. Results of the 2010 census indicate both counties are among the most rapidly developing counties in the state with population growth greater than 25% during the period of 2000-2010 (http://www.wral.com/news/national_world/national/flash/9204746/). Typically as development increases, the input of nutrients (through both surface and groundwater), silt, and other pollutants into the aquatic system increases. Increased input of these pollutants into the stream from point and non-point sources may result in eutrophication, decreased dissolved oxygen concentration, increased acidity and conductivity, and other changes in water chemistry. Poorly planned development within the watersheds of streams feeding areas that formerly harbored the Magnificent Ramshorn or that may provide potential habitat for the species also has the potential to reduce groundwater levels, which could have a serious adverse effect on pH, water hardness, and salinity levels.

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>.

Currently, because the species appears to be extirpated in the wild, collecting is not considered a threat to the species. However, its rarity and large size could conceivably generate interest to scientific collectors and possibly aquarium and pond enthusiasts. Unauthorized collecting by private and institutional collectors, hobbyists, or others could pose a significant threat to potential future efforts to reestablish the species in areas within its former range.

C. Disease or predation.
Diseases of aquatic snails are poorly known and it is currently unknown whether disease poses a threat to the species.

Also, prior to its extirpation from the wild, the Magnificent Ramshorn and its eggs were undoubtedly consumed by various predators, including other aquatic snails (species like the marsh ramshorn [*Planorbella trivolvis*] are believed to feed on the eggs of other snails), predatory insects, snail-eating fish such as the redear sunfish (*Lepomis microlophus*), amphibians and aquatic reptiles (e.g., aquatic turtles and bullfrogs), small mammals, and waterfowl and wading birds (Baker 1943, p. 19 and Wood 2004, pp. 1, 11, and 12). Predation by naturally occurring predators is a normal aspect of the population dynamics and generally would not be considered to pose a significant threat to a healthy population. However, if a predator or predators were to obtain access to the refuge population, the only known surviving individuals of the species, this could potentially lead to the species' extinction. Also, predation could be a limiting factor to recovery of the Magnificent Ramshorn in the wild by affecting potential future efforts to reintroduce the species within its historic range.

In 2012, the snails at the NC State University's Aquatic Epidemiology and Conservation Laboratory were being exclusively held in indoor aquaria. There was fairly substantial mortality early on. Two primary problems were observed: poor shell quality and a histopathology analysis indicated a systemic bacterial infection. In 2013, shell quality issues appear to have been mitigated by providing additional aeration, full spectrum lights (for Vitamin D production), and adding calcium to the tanks. In addition, two outdoor tanks have been installed to allow for natural light exposure.

After a period of substantial success rearing juvenile snails, and a substantial increase in the captive population the population experienced substantial mortality. Individual snails were lethargic, and their foot would protrude without it being associated with locomotion. Specimens were obtained and processed for histopathologic evaluation. Upon histopathologic review, the snails that were examined displayed evidence of a systemic bacterial infection. *Bacilli* were observed in multiple tissues. Aerobic cultures of tissue inoculums from moribund snails grew a multitude of organisms, however, no consistent isolate was made that could be associated with the tissues obtained from the affected snails.

It was hypothesized that the clinical problems and mortality were associated with the systemic infections noted during histopathologic examination. Snails were treated with an antimicrobial in an experimental design. Unfortunately, the experiments were unsuccessful in determining the causes of mortality because of potential cross-contamination that may have occurred between the treated and untreated tanks, or because of potential changes in nitrifying bacteria essential for

mitigating the presence of toxic ammonia and nitrite in the aquaria. Additional research is needed to determine the nature and cause of the infection and mortality observed, as well as the short and long-term effects of changes in pH and other rearing parameters. Substantial additional work is needed to optimize the diets of the snails when held in captivity.

D. The inadequacy of existing regulatory mechanisms.
The Magnificent Ramshorn is currently listed by the state of North Carolina as an endangered species. However, this designation does not protect the species from "incidental" harm, injury, death (impacts resulting from activities not specifically intend to the harm the species) or provide any protection to the species' habitat except on state-owned lands. In addition, neither the state nor the local governments with jurisdictions within the watersheds of streams in the lower Cape Fear River Basin currently have regulations/ordinances that are adequate to protect the species from the effects of agriculture, private forestry, and residential and industrial development activities (e.g., loss of riparian buffers, point and non-point source pollution, and groundwater contamination).

E. Other natural or manmade factors affecting its continued existence.
Climate change and sea level rise pose a significant long term threat to the survival of the Magnificent Ramshorn. As previously noted, the Magnificent Ramshorn is salt intolerant and saltwater intrusion into its habitat is one of the primary factors that has contributed to its extirpation in the wild. During the past century, sea level has risen by roughly 20.32 centimeters (8 inches) and available information indicates the rate of sea level rise is increasing (US Global Change Research Program [USGCRP] 2009, p. 18). While future rates of sea level rise are uncertain and dependent upon ice sheet response to climate change, continued sea level rise threatens the southeastern US coastal zone with retreat of shorelines, inundation of coastal wetlands and streams, and increased salinity of estuaries, coastal wetlands, and tidal rivers and creeks, pushing freshwater coastal ecosystems further inland. In addition, in the future the southeastern US is threatened with potential higher average temperatures (resulting increased evaporation rates), less frequent rain fall (resulting in potentially more frequent and longer dry periods), and an increase in intensity of storm events, including hurricanes; all of which are likely to increase the rate and upstream distance of salt water intrusion into coastal streams. Also, higher average temperatures and longer periods between rainfall events, together with increased development and human population levels in Brunswick and New Hanover Counties, will result in an increase demand on freshwater systems for drinking, irrigation, and other water needs, exacerbating the effects of sea level rise on streams in the lower Cape Fear River basin which encompasses the entire known historic range of the Magnificent Ramshorn (adapted from USGCRP and references therein 2009, pp. 1111-116).

During his initial attempt to propagate the Magnificent Ramshorn, Wood (2004 pp. 8 and 12) documented hybridization between the Magnificent Ramshorn and the more common marsh ramshorn (*P. trivolvis*). Although hybridization is not believed to have played a significant role in the extirpation of the Magnificent Ramshorn from the wild, it could adversely affect efforts to recover the species.

CONSERVATION MEASURES PLANNED OR IMPLEMENTED

In early 2012, a small (35 individuals) captive population was established at NC State University's Veterinary School's Aquatic Epidemiology Conservation Laboratory in Raleigh, North Carolina. These captive snails reproduced successfully, however problems with shell quality and high mortality were observed. While the shell quality issues have been successfully mitigated, efforts are still underway to treat possible symptoms that cause the bacteria-based mortality. In 2014, an outdoor tank was set up to compliment the indoor tank. Spatterdock is also being reared in an additional outdoor tank, with hopeful snail introduction to that tank in 2016. A "CVM Snail Team" of veterinary students has formed to help with the care of the snails. In 2018, snails were moved to a new lab, consisting of 4 200gal tanks, to be expanded to several more tanks, with a focus on producing large numbers of snails for possible introductions in the wild. Several potential introduction locations are being explored by Service and NCWRC staff.

Additional facilities for holding and propagating the Magnificent Ramshorn at the NCWRC's hatchery in Watha, North Carolina were established in 2011. Initial efforts at the Watha hatchery were deemed unsuccessful, however a few adult snails survived and were allowed to overwinter (2012) in an established tank. The Hatchery expanded its snail holding capacity in summer 2013 with the addition of a second 600-gallon tank. Results of water quality tests in the second Watha tank allowed the addition of a dozen snails from the 2012/2013 cohorts in August 2014. In 2015, the Hatchery added two tanks as well as a spatterdock nursery area. Initially those two tanks supported *P. magnifica*, but when the hatchery attempted to add two more tanks, they noticed there were no more living snails in any of their tanks. SAV introduced in 2012 still appears to be thriving, and although attempts to introduce seedling spatterdock to both tanks have been unsuccessful, the spatterdock nursery area has healthy growing plants. All Watha tanks are outfitted with 30% shade cloth and screen covers to exclude leaf litter and large predatory animals. In 2018, NCWRC hired a 2-year snail technician position to focus on Magnificent Ramshorn husbandry at the Watha Hatchery. The NCWRC subsequently moved all snails to their Conservation Aquaculture Center in Marion, North Carolina.

In 2008, biologists with the Service, NCWRC, North Carolina Department of Transportation (NCDOT) and Andy Wood met to evaluate some of the borrow pit ponds in Brunswick and New Hanover Counties to determine their suitability as habitat for the snail. One pond on a tract of land was identified as a likely location, however efforts to obtain funding to acquire the property were unsuccessful.

In 2012, NCWRC staff assessed the availability of potential habitat on their property at Holly Shelter Gamelands in Pender County, North Carolina. No ponds currently exist that would be suitable for the Magnificent Ramshorn, and despite initial ideas to create pond habitat that could allow a population to be established in the wild, no appropriate sites appear to be available.

In 2012-2013, several potentially suitable locations, including a portion of Orton Pond, McKinzie Pond, Pleasant Oaks Pond (Sand Hill Creek/Big Pond), and nearby Pretty Pond, were all brought under single ownership. In 2014, the landowner approached the Service to determine the possibility of restoring the snail to Big Pond at the Pleasant Oaks Plantation. A proposal to

assess snail restoration potential under a Candidate Conservation Agreement with Assurances has been formulated but not agreed upon.

In 2015, NCWRC, USFWS, and The Nature Conservancy (TNC) began to consider the potential to grow Magnificent Ramshorn snails in a borrow pit on the Green Swamp Preserve in Brunswick County. NCWRC and the Service translocated spatterdock to the pond in fall 2017, but they plants did not survive the 2018 summer. In addition, pH values of the borrow pit pond were very low (between 4-5), therefore the Green Swamp location is no longer deemed suitable for introduction of Magnificent Ramshorn snails.

The NC Division of Water Resources and the Service are working with the city of Wilmington, North Carolina to improve the water quality of Greenfield Lake which formerly supported the species (Greenfield Lake is currently on the state's list of impaired water bodies).

In 2018, Service Staff performed a desktop analysis to determine the suitability of potential habitats within the former range to support introduction of Magnificent Ramshorn snails. The results of the analysis are being used by staff to field verify suitability of potential locations. In preparation for potential introduction, the Service has drafted experimental protocols to detail necessary steps for possible introduction of the species into the wild. Further, the Service is in the process of drafting a Candidate Conservation Agreement with Assurances for landowners interested in contributing to the conservation of the species.

In 2019 and 2020, Service Staff met with Department of Defense (DoD) and the NC Plant Conservation Program (PCP), both landowners with several ponds on their properties within the historical range of the Magnificent Ramshorn. The DoD's Military Ocean Terminal Sunny Point is immediately adjacent to the private property last-known to have the species in the wild. The PCP owns ponds in the same watershed as the historical locations. Both are amenable to having water quality analyses to determine whether their ponds could be suitable habitat for snail introduction, and that habitat assessment work began in 2021 under the lead of NCWRC.

A 2019 legal settlement between NCDOT and plaintiffs for the Complete 540 transportation project includes $250,000 for Magnificent Ramshorn propagation. The road project is not expected to impact the Magnificent Ramshorn, but funds were appropriated for the species pursuant to the agreement. This funding source secures support for propagation to the future while we work on reintroduction site assessment and landowner agreements.

SUMMARY OF THREATS

While several factors have likely contributed to the apparent extirpation of the Magnificent Ramshorn in the wild, the primary factors include loss of habitat associated with: 1) the extirpation of the North American beaver in the region in the early 20th century; 2) increased salinity and other water chemistry changes, and alteration of current and flow patterns in the main river channel and tributary streams in the lower Cape Fear River Basin resulting from navigational improvements to the lower Cape Fear River channel, beginning in the early 19th century and continuing into the present; and 3) increased input of nutrients and other pollutants

from development activities adversely affecting water quality/chemistry and leading to increased nuisance aquatic plant and algae growth and efforts by landowners to control this aquatic plant and algae growth that are harmful to the snail and the aquatic vegetation it requires (Adams 1993, pp. 8-13, 23-24 and 21-22). Salt water intrusion resulting from storms (Wood pers. comm. 1995) and prolonged drought conditions (Wood pers. comm. 2008) are also factors that are believed to have contributed to, or resulted in, recent population extirpations of the species. The effects associated with navigational improvements within lower Cape Fear River Basin, development activities, nuisance aquatic plant control, and severe storms and prolonged drought conditions, as well as other factors, continue to limit available habitat of the species, threatening the species survival.

The Magnificent Ramshorn is believed to be extirpated in the wild. The only known surviving individuals of the species are currently being held and propagated at a private residence near Hampstead, North Carolina, at NC State University's College of Veterinary Medicine's Aquatic Epidemiology Conservation Laboratory in Raleigh, North Carolina, and at the NCWRC's Conservation Aquaculture Center in Marion, North Carolina. A catastrophic event such as severe storm, disease, or predator infestation, or other event affecting these refuge populations could result in extinction of the species. We continue to find that this species is warranted for listing.

RECOMMENDED CONSERVATION MEASURES

Assuring the long-term survival of the Magnificent Ramshorn will require, at a minimum: 1) providing resources to assist with maintaining the current refuge populations of the Magnificent Ramshorn, currently the only known surviving individuals of the species; 2) continuing to expand holding and controlled propagation of the species to include additional facilities and locations; 3) restoring and/or protecting water and habitat quality of streams and pond systems formerly providing habitat of the species; and 4) reestablishing populations of the species within the historical range and protecting these populations from existing and future threats. This will require: 1) additional research on the threats to the Magnificent Ramshorn and environmental requirements of the species; 2) compliance with existing federal, state, and local regulations; 3) where necessary, improvements to regulations, land use plans, etc. (e.g., increased protection of surface and ground water quality and quantity); 4) assistance from landowners/land managers, the public, and local governments and industries in identifying potential sites for reestablishing populations of the species and implementing conservation measures necessary for restoring and protecting these areas from current and future threats; and, 5) developing agreements with landowners and other partners to provide for reintroduction of the species within its former range.

LISTING PRIORITY

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
High	**Imminent**	Monotypic genus	1
		Species	**2***
		Subspecies/population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/population	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:

Magnitude:
The Magnificent Ramshorn appears to be extirpated from the wild due to habitat loss and degradation resulting from a variety of human-induced and natural factors. The only known surviving individuals of the species are presently being held and propagated at a private residence, and at two labs at NC State University's Veterinary School and NCWRC's Conservation Aquaculture Center.

Imminence:
While efforts have been made to restore habitat for the Magnificent Ramshorn at one of the sites known to have previously supported the species, all of the sites continue to be affected and/or threatened by the same factors (i.e., salt water intrusion and other water quality degradation, nuisance aquatic plant control, storms, sea level rise, etc.) believed to have resulted in extirpation of the species from the wild. Currently, only three captive populations exist; a captive population of the species comprised of approximately 775 adults, one with approximately 100 adults, and one with <100 adults. Although at least one robust captive population of the species has been maintained since 1993, a single catastrophic event, such as a severe storm, disease, or predator infestation, affecting the captive populations could result in the near extinction of the species.

Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed? Yes

Is Emergency Listing Warranted? No

DESCRIPTION OF MONITORING
Because all wild populations are believed to be extirpated, monitoring currently occurs only for the captive populations. Evaluation of possible reintroduction sites continues.

In 2020 and 2021, the following species experts maintained communication about ongoing efforts to propagate and conserve the snails, and updated information for the species assessment was included for the annual Candidate Notice of Review: Brena Jones, Aquatic Wildlife Diversity Biologist with the NCWRC; Andy Wood, President of Coastal Plain Conservation Group; Chris Eads with the NC State University's College of Veterinary Medicine's Aquatic Epidemiology Conservation Laboratory; and Hans Lohmeyer with the NCWRC's Conservation Aquaculture Center. Information provided by those species experts has been included in this assessment.

COORDINATION WITH STATES
Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment: North Carolina

Indicate which State(s) did not provide any information or comments: n/a

LITERATURE CITED
Adams, W.F. 1990a. Planorbella magnifica (Pilsbry 1903) Magnificent Ramshorn. In: A report on the conservation status of North Carolina's freshwater and terrestrial molluscan faunas. Prepared by North Carolina Scientific Council on Freshwater and Terrestrial Mollusks. 246 pp.

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Wood, A. 2004. Progress Report for the Magnificent ram-shorn snail project. Unpublished report to the US Fish and Wildlife Service, Asheville, North Carolina. 15pp and attachments.

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APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:  7/8/2021

Regional Director, U.S. Fish and Wildlife Service Date

Concur:  03/31/2022

Director, U.S. Fish and Wildlife Service Date

Do not concur: _____

Director, U. S. Fish and Wildlife Service Date

Director's Remarks:

Date of annual review: 6/10/2021
Conducted by: Thomas Augspurger, Raleigh ES Field Office