SOUTHEAST PARTNERS IN AMPHIBIAN AND REPTILE CONSERVATION

Figure 1. An adult ornate chorus frog (*Pseudacris ornata*; left) and tadpole (right). Photos: Ben Thesing-L and John Jensen-R.

Conservation Action Plan

Ornate Chorus Frog (*Pseudacris ornata*)

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Introduction

The ornate chorus frog (*Pseudacris ornata*), once common throughout its range, has experienced population extirpations and declines since perhaps as early as the 1990's. Since 2005, ornate chorus frogs have been included, though not listed, in the state wildlife action plans for Louisiana, Mississippi, and Florida (United States Geological Survey [USGS] 2021) as well as listed as state endangered in North Carolina since 2017 (North Carolina Administrative Code 15A 1977 & rev. 2017). While abundant in some areas, particularly in Georgia and Alabama, ornate chorus frogs are increasingly considered as declining. Of particular concern are population extirpations in Florida and North Carolina, along with a range-shift northward in peninsular Florida (Enge et al. 2014)

Ornate chorus frog populations may be declining due to habitat loss, fragmentation, climate change, and/or disease. However, few long-term studies of ornate chorus frog populations have been conducted range-wide, and existing knowledge gaps inhibit a robust assessment of the status of ornate chorus frogs range-wide. The conservation management practices in this report are recommendations to ensure this once common species remains common. Partners including governmental agencies, natural resource managers, academic institutions, and non-profit organizations can all play an important role in ensuring the persistence of ornate chorus frogs.

Figure 2. Adult ornate chorus frogs with green (top) and gray (bottom) coloration. Photos: Kevin Hutcheson

Species Profile

Taxonomy: Ornate chorus frogs belong to the "treefrog" family of anurans (Hylidae) and have adaptations suitable for climbing such as adhesive toepads despite their fossorial habits. The name *Pseudacris* comes from the Greek *pseudes* meaning "false" and *akris* meaning "locust" and possibly references the trill-like call of most chorus frogs. The specific epithet, *ornata*, is Latin for "decorated" and references their numerous dorsal spots and bars (Holbrook 1836). No subspecies are recognized. There is evidence for three geographically based clades: Southern Clade (Apalachicola River), Central Clade (Georgia and South Carolina), and Northern Clade (remaining northerly populations). These clades are isolated by distance, rather than geographic barriers, and divergence is likely occurring due to genetic drift and migration (Degner et al. 2010).

Description: The following has been adapted from Jensen (2008), Dorcas and Gibbons (2008), and Glorioso (2010). The ornate chorus frog is the largest southeastern

chorus frog but is still small and stout. Adults are typically 25 – 40 mm (snout to vent length) at maturity. The skin is smooth and variably colored, most often gray, brown, reddish-brown, pinkish, or green (Figures 1 and 2). Adult frogs have well-defined markings lined in white, including a black to dark brown stripe extending from the nostril through the eye and along the sides. This stripe may break up along the rear of the body with an elongated blotch on each side above the groin. The exposed surfaces of the limbs are often marked with dark bars that do not extend to the underside. The groin and thigh may have some yellow. Some individuals have a triangular mark on the top of the head between the eyes or markings along the back. Males may have darkened throats during the breeding season. The toepads are rounded but not enlarged. Ornate chorus frogs can be distinguished from other chorus frogs within their range by their stout bodies, porcelain-like coloration, bold facial stripe, and elongated side blotch.

Tadpoles are variable shades of reddish-brown to black with two brassy stripes on the sides of the back (Figures 1 and 3). The tail musculature can be bicolored in young tadpoles (light above, dark below), but this fades in larger tadpoles. A very high, clear tailfin extends up the back to just behind the eyes; this feature distinguishes it from most other southeastern tadpoles. The similar barking treefrog's tailfin is more rounded overall with a dark saddle spot (small tadpoles only), and the Cope's gray treefrog tailfin has a prominent flagellum; these features distinguish them from ornate chorus frog tadpoles.

Figure 3. Ornate chorus frog tadpole with dorsal stripes. Photo: Kevin Enge

Habitat: Ornate chorus frogs are restricted to the Coastal Plain (Brown and Means 1984; Jensen 2008). These highly fossorial frogs often shelter under woody debris or burrow within or near the roots of herbaceous ground vegetation and require easily penetrated sandy soils (Harper 1937; Carr 1940; Brown and Means 1984; Jensen 2008; Burrow et al. 2021). Adults and juveniles show no apparent discrimination, apart from soil type, among upland habitats (Palis and Aresco 2007) and can be found in a variety of land-cover types such as pine savannas, pine flatwoods, sandhills, and pine-oak forests as well as fallow agricultural fields. Breeding occurs in fishless ephemeral wetlands including marshes, cypress savannas, sinkhole ponds, and Carolina bays, but also in cypress/gum swamps, and less frequently in borrow pits and ditches (Jensen 2005, 2008; Liner et al. 2008). Breeding occurs in shallow margins of ponds that are open to sunlight with submerged and emergent aquatic vegetation to provide shelter for tadpoles (Seyle and Trauth 1982; Sekerak et al. 1996; Jensen 2008).

Life History/Behavior: Outside of their mid-winter breeding season, ornate chorus frogs typically remain in their underground burrows. Their fossorial habits may be an adaptative response to predation. Documented predators of adults include hognose

snakes (*Heterodon* spp.) and ants (Neill 1952; Burrow et al. 2021). Potential predators of adults and tadpoles include salamander larvae, aquatic invertebrates such as water beetles, snakes, wading birds, and small mammals (Jensen 2008). During heavy rain and high humidity, particularly at pre-dawn and early evening, frogs are more active on the surface (Jensen 2008; Burrow, personal observation).

Breeding primarily occurs from November to March in fishless ponds, with males arriving and staying longer than females (Ashton and Ashton 1977). The call is a sharp, metallic, regular peep likened to a hammer hitting steel (Dorcas and Gibbons 2008). Choruses can be heard as early as October and as late as April. Males usually call from grass clumps or woody detritus in shallow water (Ashton and Ashton 1977; Jensen 2008). Eggs are attached to submerged grasses in small, loose masses of 10 – 100 eggs, with 20 – 40 eggs being most typical (Seyle and Trauth 1982; Jensen 2008). Eggs hatch within a week. Tadpole diets are unknown but likely consist of algae, periphyton, and detritus. Metamorphosis occurs within about 90 days, with mature tadpoles reaching up to 43 mm prior to transformation (Jensen 2008). Juveniles are typically 14 – 16 mm with similar coloration as adults, though markings may become bolder and more distinct with maturity (Jensen 2008; Burrow, personal observation). Juvenile dispersal distances are unknown but likely limited (Ashton and Ashton 1977; Palis and Aresco 2007; Jensen 2008)

Juvenile and adult diets are poorly documented but likely contain various insects, earthworms, and nematodes. Maturity occurs within the first year. Similar to most frogs, tadpole and juvenile mortality is high and variable. Individuals that successfully emigrate live 1-2 years; most mortality is associated with predation and breeding conflicts (Caldwell 1987). Captive individuals have lived as long as 4 years (Burrow, personal observation).

Distribution: Ornate chorus frogs are restricted to the southeastern Coastal Plain (Figure 4). The species has been documented in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and the extreme eastern portion of Louisiana (Jensen 2005). The southernmost population occurs in Lake County, Florida. They are likely limited by suitable soil for burrowing and winter rain frequency (Brown and Means 1984). Significant changes from their historical distribution have not been reported.

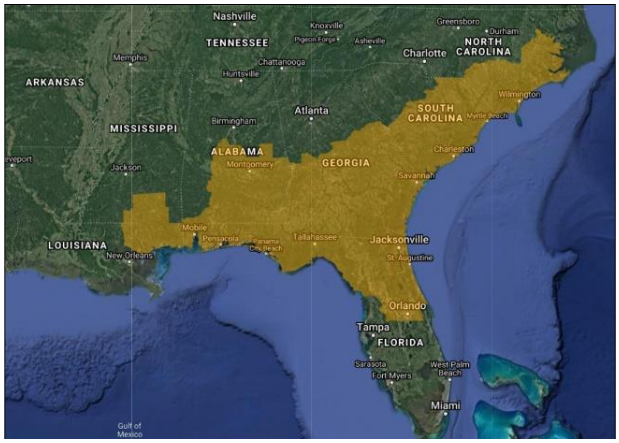

Figure 4. Ornate chorus frog distribution (Berkely Mapper 2021)

Conservation Status

Population Trends: Ornate chorus frogs were characterized as “common” and “abundant” into the mid-1990’s (Strecker 1926; Carr 1940; Martof et al. 1980; Pechmann et al. 1989; Gibbons and Semlitsch 1991; Wilson 1995). Anecdotal reports of declines and threats to population persistence emerged as early as the 1970’s in

peninsular Florida (Enge 2019) and in the 1990's to early 2000's elsewhere (Pechmann et al. 1991; Wigley et al. 1999; Means and Means 2000; Daszak et al. 2005). Unfortunately, few long-term population studies across the ornate chorus frog's range have been conducted.

In South Carolina, Caldwell (1987) reported stable ornate chorus frog population sizes at Rainbow Bay, Savanna River Site, with successful recruitment despite annual fluctuations through 1982. However, analyzing data from 1978 – 2004, Daszak et al. (2005) reported a significant decline in the number of breeding females and in juvenile recruitment. Declines in amphibian populations, including ornate chorus frogs, were attributed to an increased frequency of years with insufficient rainfall to maintain suitable hydroperiods in breeding wetlands (Daszak et al. 2005). Also on Savannah River Site, low recruitment at Sun Bay from 1978 – 1982 was attributed to installation of a drainage ditch that reduced the wetland size and hydroperiod (Caldwell 1987).

In the Florida panhandle, ornate chorus frog populations during a 2009 – 2014 study at St. Mark's Wildlife Refuge were stable (Davis et al. 2017). However, this stability was attributed to high redundancy due to a high density of wetlands of variable hydroperiod that can serve as refuges during periods of drought, flooding, and storm surge (Gunzburger et al. 2010; Davis et al. 2017). Erwin et al. (2016) reported abundance ranging from 23 – 282 individuals at two wetlands 0.5 km apart on Eglin Air Force Base from 2010 – 2015. A third wetland, 12 km from the others and surveyed from 1994 – 1995, detected 149 and 137 ornate chorus frogs, respectively (Erwin et al. 2016). While this suggests robust populations at Eglin Air Force Base, repeated surveys accounting for detection probability and assessing recruitment success are needed. In a four-year distributional survey from 2010 – 2014, Enge et al. (2014) compared the current and historical distribution of ornate chorus frogs and inferred severe declines in peninsular Florida but not in the panhandle (Enge et al. 2014). While data are limited, populations in Florida are suspected to be declining (K. Enge, personal communication).

There are no other long-term studies of ornate chorus frog populations. However, the available studies suggest that ornate chorus frogs can be resilient to stochastic disturbance (e.g., drought) and catastrophic events (e.g., loss of individual wetlands) provided that there are abundant wetlands across the landscape, in close proximity to one another, and representing a range of hydroperiods. Unfortunately, given their limited dispersal distance (Ashton and Ashton 1977; Palis and Aresco 2007), near-annual rate of turnover (Caldwell 1987), and the historical destruction of

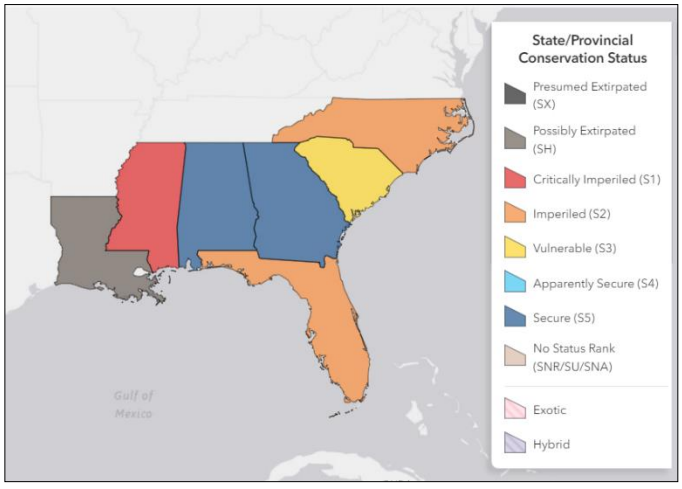

Figure 5. The state conservation status for the ornate chorus frog across its distribution (Jackson and Hammerson 2021)

short hydroperiod wetlands across the Southeast (Van Lear et al. 2005), the resiliency of ornate chorus frogs across their range is likely eroding. Habitat fragmentation and disturbance may limit gene flow and the ability of ornate chorus frogs to adapt to long-term environmental change (Degner et al. 2010). Declining populations at the range periphery (Figure 5), particularly in the states where ornate chorus frogs were historically abundant, further suggest a limited ability to adapt to long-term environmental change (i.e., climate change). However, knowledge is currently lacking to test these hypotheses.

Listing Status: The IUCN Red List of Threatened Species classifies the species as stable range-wide. However, ornate chorus frogs have been included since 2005 in State Wildlife Action Plans for 4 out of 7 states in which they occur (USGS 2021). In Louisiana, ornate chorus frogs are possibly extirpated and listed as "historically occurring". In Mississippi, ornate chorus frogs are considered "critically imperiled." In North Carolina, the species is listed as "endangered". The peninsular Florida population of the ornate chorus frog is considered a Species of Greatest Conservation Need. NatureServe — a non-profit organization that collaborates with state and private conservation entities — classifies the ornate chorus frog as "apparently secure" (G4) across its range but also finds the species "possibly extirpated" to "vulnerable" in all states except Georgia and Alabama, where it is listed as "secure" (Figure 5; Jackson and Hammerson 2021).

Threats

Threats to the ornate chorus frog include large-scale habitat loss and degradation, fragmentation of remaining habitat, climate change, and disease.

1. **Loss of breeding wetlands:** Ornate chorus frogs require fish-free wetlands with moderate hydroperiods to support successful breeding and juvenile development. Historical and current destruction of wetlands across the Southeast disproportionately affect small, ephemeral, fish-free wetlands (Frayer et al. 1983; Dahl 1990). Currently, this wetland type is not protected under the Clean Water Act (Clean Water Act 33 U.S.C. §1251 et seq. 1972). When mitigation for wetland loss does occur, current practice favors wetlands with long to permanent hydroperiods that typically support fish. This has resulted in range-wide losses of suitable wetlands.

2. **Habitat degradation in wetland and terrestrial habitats:** Agricultural practices, including ditching of wetlands, fire exclusion, and intensive site preparation, degrade wetland and terrestrial habitats for ornate chorus frogs. The near elimination of recruitment of ornate chorus frogs in Sun Bay (South Carolina) was attributed to ditching, which reduced wetland area and hydroperiod (Caldwell 1987). Across the ornate chorus frog's range, the exclusion of fire from wetlands has resulted in succession of woody plants and canopy closure within wetland basins (Van Lear et al. 2005). Wetland succession alters productivity and nutrients, which

reduces habitat quality for juvenile development (Burrow and Maerz 2021). In uplands, soil disturbance reduces the availability of refugia and may increase predation of juveniles and adults (Burrow et al. 2021). Historical habitat conversion, particularly to industrial pine plantations, is likely a contributing factor in observed declines throughout their range (Dodd 1995; Wigley et al. 1999; Means and Means 2000).

3. **Habitat fragmentation:** Ornate chorus frogs have short lifespans (1–3 years) and limited dispersal distances (< 500 m; see above). This life history strategy is an adaptation to unstable but abundant heterogenous wetland availability across the landscape. For example, during periods of drought, longer hydroperiod wetlands provide refugia from drying, whereas shorter hydroperiod wetlands provide refugia from fish predation during wetter years (Davis et al. 2007). Historical wetland losses, urbanization, and other habitat conversion types (e.g., roads, agriculture) have fragmented ornate chorus frog habitats. Degner et al. (2010) attributed reduced gene flow in some populations to fragmentation and disturbance. Fragmentation isolates populations and limits the ability of ornate chorus frogs to recolonize breeding sites following stochastic extirpation (e.g., due to drought) and adapt to long-term environmental change (Degner et al. 2010).

4. **Climate change:** Increasing temperatures across the Southeast, particularly during early spring to summer, could negatively impact ornate chorus frogs by increasing risk of wetland drying and increasing desiccation rates of migrating individuals (U.S. Global Change Research Program [USGCRP] 2018). In South Carolina, breeding initiation has moved an estimated 37.2 days earlier since 1979 and is correlated with increased overnight temperature and precipitation (Todd et al. 2011). Alteration of breeding phenology increases ornate chorus frogs' risk of exposure to extreme weather events (e.g., freezing, severe storms). In peninsular Florida, a northward shift of ornate chorus frog occurrence suggests declines there are climate related (Enge et al. 2014).

   Historically, drought and drying trends have been associated with recruitment failure (Caldwell 1987; Pechmann et al. 1991; Daszak et al. 2005; Palis and Aresco 2007). Current climate projections predict minimal change in total precipitation across the ornate chorus frog's range; however, extreme events (e.g., flooding, drought) are projected to increase in frequency. Along the coast, sea level rise and more frequent storms increase the risk of wetland inundation with sea water (USGCRP 2018). In Florida, ornate chorus frogs were not detected in previously occupied wetlands following storm surge inundation (Gunzburger et al. 2010). The ability of ornate chorus frogs to persist during periods of extreme events is linked to the availability of abundant, heterogeneous wetlands across the landscape (Gibbons et al. 2006; Davis et al. 2017).

5. **Disease:** Globally, emerging infectious diseases are increasingly threatening amphibian populations. Chytridiomycosis, a fungal disease caused by *Batrachochytrium dendrobatidis* (*Bd*), has caused declines and extinctions of amphibian species worldwide (Lips et al. 2006; Lötters et al. 2009; Fisher and Garner 2020). In North America, ranavirus infections are more commonly associated with amphibian die-offs (Miller et al. 2011; Bartlett et al. 2021). Studies of disease and disease risk in ornate chorus frogs are very limited and only recently undertaken. In an experimental study, Gervasi et al. (2017) found that ornate chorus frogs can carry very high *Bd* infection loads and had a high rate of mortality. However, in natural ponds, while Horner et al. (2017) found high *Bd* infection loads and prevalence for ornate chorus frogs, they did not observe any evidence of disease or mortality. Ornate chorus frogs have been highly susceptible to ranavirus exposure in the laboratory (Brenes 2013; S. Lance, personal communication), but prevalence and infection loads at natural wetlands appear low (S. Lance, personal communication). Disease risk and outcomes for ornate chorus frogs are likely influenced by environmental factors such as increased temperature, season, land cover, and water quality (Petersen et al. 2016; Goff et al. 2020).

Inventory and Monitoring Techniques

Extensive inventory and monitoring of populations across the ornate chorus frog range can address existing gaps in the species' life history, ecology, and status. Specific methods should be chosen depending on their suitability for addressing the study questions, planned analysis, and available resources. Due to their fossorial nature, it is rare to encounter ornate chorus frogs outside their breeding season. For this reason, most survey methods for ornate chorus frogs focus on breeding wetlands and the surrounding uplands. It is important to remember that ornate chorus frogs may not breed in a given wetland every year; therefore, multi-year surveys are required to determine presence/absence at a given site.

Similar to Enge et al.'s (2014) survey across Florida, distributional, as well as occupancy surveys, across the ornate chorus frog's range are needed to answer questions regarding population extirpations and declines. These surveys should include sites with historical occupancy records as well as sites with unknown occupancy. Google Earth or other satellite imagery can be used to detect potentially suitable wetlands, although breeding may occur in atypical sites that may or may not be readily identified using aerial imagery (e.g., roadside ditches, flooded yards or agricultural lands; Jensen 2005; L. Smith, personal communication). A record of specific site locations (i.e., GPS coordinates) should also be generated to ensure the same sites can be repeatedly sampled over time. Detection of ornate chorus frogs depends on numerous factors, including observer experience, season, and weather. Repeated surveys at individual sites are required to account for detection probability and generate robust estimates of site occupancy and abundance.

For sites with known occupancy, monitoring can be targeted to generate additional information such as abundance, breeding/recruitment, and pathogen/disease prevalence. Below are some inventory and monitoring techniques that PARC suggests stakeholders and land managers use to obtain information on abundance, diversity, and distribution of amphibians, including ornate chorus frogs (Graeter et al. 2008).

1. **Dip-net surveys:** Dip-net surveys use hand-held nets that are swept through an aquatic habitat to capture amphibians. This survey type can be effective for determining occupancy, abundance, and evidence of breeding. Dip-net surveys are most useful for detection of tadpoles. Surveys should be timed to begin no earlier than breeding initiation; tadpoles can be detected for up to 4 months after cessation of breeding activity. All areas of the habitat should be sampled equally using a standardized procedure to ensure repeated samples have equal sampling effort.

2. **Auditory surveys:** Auditory or acoustic monitoring, also known as call surveys, is conducted either in-person or using automated recording devices (ARDs; e.g., frogloggers). Call surveys are an effective method for estimating occupancy of wetlands and adult populations. Listening sites are established at or near potential breeding habitat, and trained observers listen and record frog calls and call intensity for 5 minutes. ARDs are usually deployed for an entire breeding season but often set to record at night or specified intervals. A trained technician or specialized software is used to analyze the recordings.

3. **Terrestrial drift fence with traps:** Terrestrial drift fencing with pitfall or funnel traps is a proven method for capturing adult and juvenile amphibians as they move into and out of breeding wetlands. This method is used for mark-recapture studies and long-term population monitoring to determine population demographics such as abundance, sex ratios, and recruitment. Drift fences are usually constructed of plastic silt-fencing or aluminum or galvanized flashing partially buried underground. Pitfall traps are buckets or other containers buried at intervals alongside or on the ends of fencing. Funnel traps are cylindrical traps with a tapering funnel entrance constructed of aluminum window screen or hardware cloth. Ornate chorus frogs are great climbers and funnel traps may yield higher captures by preventing escape (Enge 2001). Animals moving along the fence enter the trap; large numbers of individuals can be captured during peak breeding and emigration. A wetted sponge placed in the trap and frequent checks will help prevent mortality. Running drift-fence traps requires a large investment of time, labor, and cost. Disturbance caused by installation may also attract predators including fire ants (e.g., Red imported fire ant, *Solenopsis invicta*).

4. **eDNA:** Ornate chorus frogs are readily captured and identifiable by traditional methods. However, environmental DNA (eDNA) methods can be useful for detection on sites where logistical constraints preclude the use of traditional survey methods. In brief, eDNA surveys include collection and filtration of multiple water samples per wetland. In the laboratory, trace DNA shed by the target organism is extracted and

analyzed using quantitative polymerase chain reaction (qPCR) to determine if the species' DNA is present in the sample and in what quantity. Specific methods for ornate chorus frogs are detailed in Goldberg et al. (2017). In that study, accurate detection of ornate chorus frogs depended on wetland pH. At low pH (< 5), increased sampling and sample volume were required to achieve detection comparable with dipnet surveys (Goldberg et al. 2017).

Study designs that include covariates for habitat and environmental variables will be most useful in determining the causes of ornate chorus frog persistence and population declines. Regardless of monitoring method, detection variables (e.g., temperature, date/time, precipitation) and habitat variables (e.g., wetland size, hydroperiod, canopy cover, landscape variables) should be recorded. When animals are captured, morphometrics (e.g., total length, snout-to-vent-length, mass, sex) and body condition should be noted. Additionally, given the uncertain role of disease in ornate chorus frog ecology, it is important to monitor for signs of disease and pathogens including *Bd* and ranavirus. Use sanitation practices for all monitoring activities (NEPARC Disinfection Protocol).

Recommended Conservation and Management Strategies

Conservation of ornate chorus frogs depends on maintaining suitable wetland breeding habitat as well as upland terrestrial habitat. Listed below are best management practices, based on the existing knowledge of the natural history of and threats to ornate chorus frogs.

1. **Conserve heterogeneous wetland complexes:** Habitat loss is the leading suspected cause of ornate chorus frog declines (Enge et al. 2014). The suitability of a single wetland to support successful breeding and recruitment may vary from year to year. For this reason, the persistence of ornate chorus frogs is linked to the availability of abundant, heterogeneous wetlands across the landscape (Gibbons et al. 2006; Davis et al. 2017). Abundant wetlands increase the probability that, in any given year, some wetlands will support breeding and recruitment. Wetlands with varying hydroperiods can promote metapopulation stability by providing refuge from stochastic events such as extreme weather, fish intrusion, and disease outbreaks (Semlitsch and Bodie 1998). In areas lacking a suite of natural wetlands of varying hydroperiods, construction of grassy, artificial wetlands (e.g., borrow pits) of varying depths might help ornate chorus frog populations persist on the landscape.

2. **Use fire management practices to restore breeding wetlands:** Ornate chorus frogs require open-canopied, herbaceous wetlands for successful breeding and tadpole development. In the absence of warm season fires when wetlands are dry, shrubs and trees often replace herbaceous vegetation. Altered plant communities can make the habitat unsuitable for breeding or lower survival and growth of tadpoles (Burrow and Maerz 2021). Alternatives to prescribed fire (e.g., cutting, herbicide treatments) have been used to successfully restore open canopies

(Klaus and Noss 2016). However, fire management is required to restore herbaceous plant communities and maintain wetlands long term (Martin and Kirkman 2009).

3. **Limit anthropogenic disturbance:** Ornate chorus frogs are sensitive to anthropogenic disturbance (Caldwell 1987; Dodd 1995; Wigley et al. 1999; Means and Means 2000; Enge et al. 2014; Burrow et al. 2021). Ornate chorus frogs generally remain within 500 m of breeding wetlands though dispersing juveniles may move farther. Preventing soil disturbance within this zone will ensure suitable foraging and burrowing habitats. Restoring historically disturbed ground cover may also benefit ornate chorus frogs (Burrow et al. 2021).

4. **Follow best practices on productive lands:** Ornate chorus frogs have been shown to re-establish on former agricultural lands and use ecologically managed forests though long-term persistence in these habitats has not been assessed (Brown and Means 1984; Caldwell 1987; Palis and Aresco 2007; Owens et al. 2008; Todd et al. 2009). Where other conservation measures are unfeasible, best practices such as limiting pesticides, herbicides, and soil disturbance as well as the use of prescribed fire are recommended. Wetlands within silvicultural and agricultural areas should be maintained with buffer zones of natural vegetation (Semlitsch 2000).

5. **Monitor populations:** Long-term monitoring is required to document potential declines of ornate chorus frogs range-wide. Monitoring can also provide an early warning of potential declines and disease outbreaks as well as provide information to assess population dynamics. Long-term monitoring can also provide ecological and natural history details needed to understand how ornate chorus frogs respond to environmental change including climate change. Surveys of historical sites and suitable sites with unknown occupancy will help determine the status of ornate chorus frog populations.

6. **Headstarting:** Headstarting is the practice of collecting amphibian eggs from source populations and rearing them, typically in outdoor cattle tanks, through metamorphosis. Juveniles are released to bolster struggling populations, re-establish extirpated populations or start populations within suitable but unoccupied habitat. This strategy has been started in North Carolina through a collaborative effort between North Carolina Zoo and the NC Wildlife Resources Commission. The group followed standard amphibian rearing protocols with shallower water especially near metamorphosis (J. Hall and D. Smith, personal communication). Floating rafts made from sponges and dry vegetation will give newly metamorphosed frogs a secure resting area and increase survival of juvenile frogs (A. Burrow, personal observation). Headstarting should only be undertaken after there is a thorough understanding of the distribution and status of extant populations. The causes of local declines or extirpations must also be ameliorated for populations to persist.

7. **Practice good sanitation when conducting field work:** Pathogens can inadvertently spread through research and monitoring activities. To minimize the

potential spread of pathogens, disinfect all equipment with 3% bleach (or other suitable disinfectants) between study sites, and if handling tadpoles or frogs, change gloves before processing each individual (see NEPARC Disinfection Protocol for more details, link in additional information section). If you encounter ornate chorus frogs, tadpoles, or other amphibians that appear diseased or unhealthy, report findings to the PARC Herp Disease Alert System. To report a possible herpetofaunal disease case, send an email to herpdiseasealert@parcplace.org. Include your name, email address, the date of the observation, and a description of what you saw and where. Also include, if you are able, the species and/or lifestage(s) involved as well as photographs. You should also submit this information to your local and state authorities.

High Priority Research Questions

Explore relationships between population dynamics and environmental characteristics

- Identify important macro- and micro-scale habitat variables for occupancy and abundance
- Understand how anthropogenic disturbance affects occupancy and abundance
- Understand how forest composition affects occupancy and abundance
- Describe possible impacts of climate change on ornate chorus frogs
- Conduct occupancy/abundance surveys throughout range

Explore relationships between management practices and demographics

- Determine how forest management and agricultural practices affect ornate chorus frogs
- Determine the response of ornate chorus frog populations to habitat restoration

Movement and spatial ecology

- Describe movement, including dispersal, of juveniles and adults
- Develop landscape-scale models of ornate chorus frog population dynamics

Improve understandings of epidemiology

- Determine pathogen prevalence and loads in natural environments
- Identify important variables for disease occurrence in natural populations

Partnering

1. **The Orianne Society.** The Orianne Society works to conserve critical ecosystems for imperiled reptiles and amphibians using science, applied conservation and education. As part of their Longleaf Savannas Initiative, they conduct land protection, active management and restoration, research, inventory and monitoring, and education-outreach throughout the southeastern United States.

2. **The Amphibian Foundation.** The Amphibian Foundation is dedicated to connecting individuals, communities, and organizations to create and implement lasting solutions to the global amphibian extinction crisis. They partner with state, federal, and academic partners to conserve several imperiled species with research, captive rearing, monitoring, and education-outreach.

3. **Species Experts.** Species experts are also highly valuable for contributing insight into the natural history of ornate chorus frogs and serve as excellent resources to land managers and others charged with the conservation of this species. The list below is not comprehensive. If you have questions about how to conserve ornate chorus frogs on a property you manage or wish to be connected with an expert, please contact PARC by visiting: https://parcplace.org/network/parc-partners/.

    a. Kevin Enge, Florida Fish and Wildlife Conservation Commission

    b. D. Bruce Means, Coastal Plains Institute and Land Conservancy

    c. Stacey Lance, Savanna River Ecological Laboratory

    d. David Scott, Savanna River Ecological Laboratory

Additional Sources of Information

AmphibiaWeb: https://amphibiaweb.org/species/1059

IUCN: https://www.iucnredlist.org/

NatureServe Explorer: https://explorer.natureserve.org/

NEPARC Disinfection Protocols: http://northeastparc.org/disinfection-protocol/

North American Amphibian Monitoring Protocol: http://www.pwrc.usgs.gov/naamp/

Savannah River Ecology Lab: http://srelherp.uga.edu

The Amphibian Foundation: https://www.amphibianfoundation.org/

The Orianne Society: https://orianne society.org

U.S. Fish and Wildlife Service: https://www.fws.gov/southeast

USGS State Wildlife Action Plans: https://www1.usgs.gov/csas/swap/index.html

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