# Species Status Assessment Report for the Eastern Black Rail (*Laterallus jamaicensis jamaicensis*)

**Version 1.2**


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**U.S. Fish and Wildlife Service**
**Region 4**
**Atlanta, GA**

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## EXECUTIVE SUMMARY

This report summarizes the results of a Species Status Assessment completed for the eastern black rail (*Laterallus jamaicensis jamaicensis*) to assess the subspecies' overall viability. The eastern black rail is a subspecies of black rail, a small, cryptic marsh bird that occurs in salt, brackish, and freshwater wetlands in the eastern United States (east of the Rocky Mountains), Mexico, Central America, and the Caribbean.

To evaluate the viability of the eastern black rail, we assessed the distribution, characterized the needs and the current condition, and predicted the future condition of the subspecies' in terms of resiliency, representation, and redundancy. In the United States, eastern black rails are found in both coastal and interior areas, but the majority of detections are from coastal sites. In a recent assessment of 23 states along the Atlantic and Gulf Coasts, approximately 90% of documented breeding-season occurrence records occurred at coastal locations and less than 10% were interior records, with over 60% of the interior records occurring before 1950 (Watts 2016, entire). In addition, the northeastern, southeastern, and interior United States differs in the quantity and quality of survey data available for the eastern black rail. When viewing historical occurrences on the state level compared to what is known of present distribution, the range contraction (from Massachusetts to New Jersey) and site abandonment (patchy coastal distribution) noted by Watts (2016, entire) appear to be occurring throughout the eastern United States. In relative terms, regional strongholds in the Southeast and Southwest still exist for this subspecies; however, the best available scientific data suggest that the remaining strongholds support a relatively small total population size across the contiguous United States, i.e., an estimated 1,299 individuals on the upper Texas coast within protected areas prior to Hurricane Harvey, and an estimated 355 – 815 breeding pairs on the Atlantic Coast from New Jersey to Florida (including the Gulf Coast of Florida). There are no current population estimates from the interior States (Colorado, Kansas, or Oklahoma), although there are consistent populations of eastern black rails at Quivira National Wildlife Refuge in Kansas and at least four sites in Colorado where the subspecies is encountered in the spring and summer. Some of the eastern black rail populations do migrate; for example, birds that breed in Colorado and Kansas migrate to Texas to overwinter. Given that we do not have consistent monitoring or survey results on the eastern black rail throughout the Caribbean and Central America, it is likely birds occur throughout this region, but we have no information to indicate that the eastern black rail is present in large numbers.

Eastern black rails occupy relatively high elevations along heavily vegetated wetland gradients, with soils moist or flooded to a shallow depth. The subspecies requires dense vegetative cover that allows movement underneath the canopy, and because birds are found in a variety of salt, brackish, and freshwater wetland habitats that can be tidally or non-tidally influenced, plant

structure is considered more important than plant species composition in predicting habitat suitability. In terms of nest success, nests must be well hidden in a dense clump of vegetation over moist soil or shallow water to provide shelter from the elements and protection from predators. Flooding is a frequent cause of nest failure for eastern black rails; therefore, water levels must be lower than nests during egg-laying and incubation in order for nests to be successful. In addition, shallow pools that are 1-3 cm deep may be the most optimal for foraging and for chick-rearing. Some elevational variability in the substrate is needed; eastern black rails require elevated refugia with dense cover to survive high water events due to the propensity of juvenile and adult black rails to walk and run rather than fly and chicks' inability to fly.

Historically, the primary stressors to the eastern black rail included habitat degradation and fragmentation from conversion of marshes and wetlands to agricultural lands or urban areas. Also, historical efforts to reduce mosquito populations included marsh draining and ditching, both of which reduced suitable habitat for the eastern black rail. The change of hay harvesting from traditional methods to mechanical methods also lead to habitat degradation and direct mortality of eastern black rails present around these areas. In addition, coastal prairie habitats in Texas were converted to pasture for cattle grazing as well as agriculture (forage, grain crops).

Based on our review of the best available science, we identified current stressors, which are slightly different than historical stressors, influencing the viability of the eastern black rail. Habitat degradation and resulting wetland loss from ditching and draining of marshes for mosquito control is not a current stressor, and conversion of wetlands to agricultural and urban areas has slowed as compared to historically. Currently, the eastern black rail is impacted by the loss, degradation, and fragmentation of wetland habitats resulting from sea level rise along the coast and ground-and surface-water withdrawals across the subspecies' range. Incompatible land management techniques, such as application of poorly timed and planned prescribed fires, intense grazing, or haying, also have negative impacts on the eastern black rail and its habitat, especially when conducted at sensitive times, such as the breeding season or the flightless molt period. Stochastic events, such as flood events and hurricanes, can also have significant impacts on populations of eastern black rail. For example, extensive flooding from Hurricane Harvey was documented at occupied sites of eastern black rail across the Texas coast, and since this flooding occurred during the flightless molt period for the subspecies, the extended period of water on the wetland surface likely impacted the subspecies.

When considering the future risk factors to the eastern black rail, there is likely a complex interaction of factors having synergistic effects on the subspecies as a whole. In coastal areas, sea level rise, as well as increasing storm frequency and intensity and increased flood events (both those associated with high tides and storms), will have both direct and indirect effects on the subspecies. The remaining extensive patches of high marsh required for breeding are projected to be lost or converted to low marsh or open water (as a result of sea level rise). In addition, there will be increasing demands on groundwater withdrawals, which will reduce soil moisture and surface water, and thus negatively impact wetland habitat. Localized subsidence is expected to occur when groundwater withdrawal rates are greater than the aquifer recharge rates. Also, warmer and drier conditions (associated with projected drought increases) will reduce overall habitat quality for the eastern black rail. Incompatible land management (such as untimely prescribed fire application and overgrazing) will continue to negatively impact the subspecies throughout its range, especially if done during sensitive time periods, i.e., the breeding season or flightless molt period.

These stressors contribute to the subspecies occupancy at sites and thus its population numbers. Some stressors have resulted in permanent or long-term habitat loss, such the historical conversion of habitat to agriculture, while other factors may only affect sites temporarily, such as a fire or annually reduced precipitation. Even local but too frequent intermittent stressors, such as unusual high tides or prescribed fire, can cause reproductive failure or adult mortality, respectively, and thus reduce eastern black rail occupancy at a site and the ability of a site to allow for successful reproduction of individuals to recolonize available sites elsewhere. While these intermittent stressors allow for recolonization at sites, recolonization is based on productivity at other sites within a generational timescale for the subspecies. If these stressors, combined, occur at frequencies within and across generations, they could limit the ability of the eastern black rail to maintain occupancy at habitat sites and also limit its ability to colonize previously occupied sites or new sites. It is likely that several of these stressors are acting synergistically on the subspecies, and the combination of multiple stressors may be more harmful than a single stressor acting alone. Although there is some inherent uncertainty surrounding the stressors we evaluated for the eastern black rail and their synergistic effects are largely unknown, this does not prevent us from making a credible assessment of the likely direction and magnitude of those impacts, even though it may not be possible to make such predictions of impacts with precision.

The eastern black rail is a widely distributed, secretive marsh bird with little known about subspecies' population structure and dynamics. The scale of analysis for the eastern black rail status assessment therefore depends largely on the scale at which differences exist across the subspecies' range. Since we did not have clear population differentiation for the eastern black rail, we used environmental data and eastern black rail occurrence point data from across the subspecies' range to develop analysis units to inform our analysis of current and future condition. We collected data points from different sources to assess the eastern black rail across its entire contiguous United States range. Since there is high spatial and ecological complexity across the range of the eastern black rail, we used a multivariate statistical technique called non-metric multidimensional scaling to account for environmental and biological complexity while designing analysis units. The analysis indicated five units (Central Lowlands, Great Plains, Mid-Atlantic Coastal Plain, Southeast Coastal Plain, and Southwest Coastal Plain) of eastern black rails. Historical data and few current records indicated the Appalachians and New England encompassed part of the range of the eastern black rail, and therefore, we identified two additional units (Appalachians and New England) for a total of seven analysis units.

Given data availability, we evaluated the current resiliency of eastern black rail analysis units (AUs) by using a dynamic occupancy analysis to estimate site colonization and persistence over time. We used high quality data from repeated presence/absence surveys across the range of the subspecies. With these analyses, we estimated the probability of presence at a site and related the occupancy probability to environmental covariates of interest. We also estimated the probability of detecting an animal if it is present because detecting animals is usually imperfect. To assess the current representation of the subspecies, we used two metrics that reflect the subspecies' adaptive capacity: 1) habitat variability and 2) latitudinal variability. The subspecies should have resilient populations across the AUs to maintain existing adaptive capacity. For redundancy, we evaluated the current distribution of eastern black rail AUs through their present-day spatial locations.

Historically, the eastern black rail occupied multiple areas of wetlands within each AU. Our results indicated that eastern black rail AUs currently have low to no resiliency in the contiguous United States (Table ES-1). The Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain AUs have low resiliency based on the occupancy model results, which indicate very low occupancy probabilities in each modelled AU: 0.25 in the Southwest Coastal Plain, 0.13 in the Great Plains, and 0.099 in the Southeast Coastal Plain. The Mid-Atlantic Coastal Plain AU currently exhibits very low resiliency for eastern black rail as it supports fewer birds and occupied habitat patches than the Southeast Coastal Plain AU. The remaining three AUs, New England, Appalachians, and Central Lowlands, currently demonstrate no resiliency. There were insufficient detections to model these units and recent detections (2011 to present) are fewer than 20 for each AU. These three units historically did not support abundances of eastern black rail as high as the other four AUs and an evaluation of current status information yields that eastern black rails are effectively extirpated from portions of the New England, Appalachians, and Central Lowlands AUs that were once occupied. Lastly, resiliency is unknown for the Central America and Caribbean portion of the eastern black rail's range. The sparsity of historical and current records, including nest records, indicates that resiliency outside of the contiguous United States is likely low.

As described above, the eastern black rail had a wide distribution and exhibited latitudinal variability of analysis units. However, three of the AUs (New England, Appalachians, and Central Lowlands) are effectively extirpated, and therefore, this latitudinal variability (higher latitudes) has effectively been lost to the subspecies. While these AUs have experienced changes in their respective environments, wetland habitats continue to be present on the landscape and the subspecies was represented in the past. In addition, the Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain AUs have low resiliency and the Mid-Atlantic AU has very low resiliency. Therefore, even though the eastern black rail still technically occurs at varying latitudes, we conclude that the subspecies currently has a low level of representation across its range. When considering habitat variability, we determined the eastern black rail has a level of adaptive potential by using similar habitats elements (i.e., higher elevation areas within wetlands with dense vegetation, moist soils, and shallow flood depth) within different wetland types within analysis units. However, there may be other factors that are not currently known that influence and affect the eastern black rail since not all apparent suitable wetland habitat is occupied.

Despite having a wide distribution, the eastern black rail currently has low redundancy across its range. With the loss of three AUs in the upper latitudes of the range, the subspecies has reduced ability to withstand catastrophic events, such as hurricanes and tropical storms, which could impact the lower latitudinal AUs. Given the lack of habitat connectivity, patchy and localized distribution, it would be difficult for the subspecies to recover from a catastrophic event in one or more AU. Considering the low to no resiliency for all AUs of the eastern black rail, this supports our conclusion that the subspecies has low redundancy across the entire range.

To predict future resiliency of eastern black rail AUs, we used a fully stochastic site occupancy, projection model. The model parameters were derived from the data analysis and were linked to environmental covariates, such as land management, and land cover change (sea level rise, development, etc.). The number of sites occupied in the future was predicted based on the current number of sites occupied. We also used the model to explore what rates of habitat loss might lead to viability for the analysis units and the subspecies. We used the projection model to predict future conditions of analysis units under five plausible scenarios that reflected differing levels of sea level rise and land management and combined effects of both. These future scenarios forecast site occupancy for the eastern black rail out to 2100 with time steps at 2043 and 2068 (25 and 50 years from present, respectively).

Results from the fully stochastic site occupancy projection model indicate the four remaining AUs (Mid-Atlantic Coastal Plain, Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain) have a high probability of extirpation (extinction) under all scenarios by 2100 (Table ES-1). The scenarios yielded similar results across the Mid-Atlantic Coastal Plain, Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain AUs with some variation in the time to extinction. However, the difference in the time to extinction among the plausible scenarios was no greater than 10 years for each AU. In addition, all AUs generally exhibited a consistent downward trend in the proportion of sites remaining occupied after the first ~25 years for all scenarios. Given that most of the predicted declines in eastern black rail occupancy were driven by habitat loss rates, and future projections of habitat loss are expected to continue and be exacerbated by sea level rise, resiliency of the four remaining AUs is expected to decline further.

We expect all eastern black rail AUs to have no resiliency by 2068, as all are likely to be extirpated by that time. We have no reason to expect the resiliency of eastern black rail outside the contiguous United States to improve in such a manner that will substantially contribute to eastern black rail viability within the United States portion of the range. Limited historical and current data, including nest records, indicates that resiliency outside of the contiguous United States will continue to be low into the future, or decline if habitat loss continues.

In our current condition analysis, we determined the eastern black rail has three AUs with low resiliency and one AU with very low resiliency. With the loss of three AUs, the latitudinal variability of these AUs has been effectively lost to the subspecies, and therefore, we determined the eastern black rail has a low level of representation currently. In terms of habitat variability, we concluded the eastern black rail has some adaptive capacity to changing environmental conditions because it uses similar habitat elements across different wetland types (salt, brackish, and freshwater); the subspecies needs these habitat elements to be present in order to survive. In the next 25 years (by the year 2043), the Great Plains AU will likely be extirpated leading to the loss of the remaining higher latitudinal representative unit for the eastern black rail. In addition to this loss, the three remaining AUs (Mid-Atlantic Coastal Plain, Southwest Coastal Plain, and Southeast Coastal Plain) will likely be lost within the next 50 years. Thus, the eastern black rail will likely have zero representation by approximately 2068.

Under current condition, we determined that the subspecies is effectively extirpated in three of the seven AUs resulting in a large range contraction and a current low redundancy for the subspecies. We analyzed the four remaining AUs under future scenarios and determined the eastern black rail will have zero redundancy under all plausible scenarios by 2100. In fact, the Great Plains AU will likely be extirpated in 15 to 25 years leading to further reduction (from a current low condition) in redundancy by 2043 and resulting in only coastal populations of the eastern black rail remaining. By only having coastal AUs remaining (and in even lower resiliency than current condition), this will further limit the ability of the eastern black rail to withstand catastrophic events such as flooding from hurricanes and tropical storms. By 2068, we expect all eastern black rail AUs to be likely extirpated.

Although the ultimate source of the widespread decline is not clear and despite that the relative role and synergistic effects of the factors are not quantifiable, the decline in eastern black rail is well documented by a previous status assessment (Watts 2016, entire) and supported by our review of the best available information and modeling efforts. Regardless of the uncertainty associated with the subspecies and the factors affecting its population size, the observed extirpation at sites used by the subspecies is expected to continue.

Table ES-1. Summary results of the Eastern Black Rail Species Status Assessment. Analysis Units = AUs.

| 3Rs | Needs | Current Condition | Future Condition |
|---|---|---|---|
| **Resiliency** (Large populations able to withstand stochastic events) | • Salt, brackish, and freshwater marsh habitats<br>• Dense herbaceous vegetative cover that allows for movement<br>• Elevated refugia to escape high water events<br>• Moist to saturated substrates interspersed with or adjacent to very shallow water<br>• Multiple occupied areas within each Analysis Unit | • AUs show low to no resiliency<br>• AUs with low resiliency<br>o Southeast<br>o Southwest<br>o Great Plains<br>• AUs with very low resiliency<br>o Mid-Atlantic Coastal Plain<br>• AUs with no resiliency (effectively extirpated)<br>o New England<br>o Appalachians<br>o Central Lowlands | Projections for 4 remaining AUs based on future scenarios to 2100<br>• Lower rate of habitat loss and positive land management practices to benefit eastern black rail; 1 AU extirpated and 3 AUs with low resiliency at 2043; 4 AUs extirpated at 2068.<br>• Moderate sea level rise and neutral land management practices, 1 AU extirpated and 3 AUs with low resiliency at 2043; 4 AUs extirpated at 2068.<br>• High sea level rise and negative land management practices, 1 AU extirpated and 3 AUs with low resiliency at 2043; 4 AUs extirpated by 2068.<br>• Poor land management practices for eastern black rail and moderate sea level rise, 1 AU extirpated and 3 AUs with low resiliency at 2043; 4 AUs extirpated by 2068.<br>• Positive land management practices and moderate sea level rise, 1 AU extirpated and 3 AUs with low resiliency at 2043; 3 AUs extirpated and 1 AU with very low resiliency by 2068; 4 AUs extripated by 2100. |

| | | | |
|---|---|---|---|
| **Representation**<br>(Genetic and ecological diversity to maintain adaptive potential) | • Ecological variation exists due to latitudinal and habitat variability<br>• Genetic variation is unknown | • Compared to historical distribution, significant range contraction<br>• Exhibits some adaptive potential by utilizing similar habitat elements within different wetland types (habitat variability)<br>• Latitudinal variability effectively lost in New England, Appalachians, and Central Lowlands | Projections for 4 remaining AUs based on future scenarios to 2100<br>• Reduced latitudinal variability under all scenarios.<br>• Exhibits some adaptive potential by utilizating similar habitat elements within different wetland types<br>• Representation effectively lost by 2068. |
| **Redundancy**<br>(Number and distribution of populations to withstand catastrophic events) | • Multiple resilient populations with each Analysis Unit<br>• Multiple resilient Analysis Units spread throughout the subspecies' range | • Reduced ability to withstand catastrophic events due to low resiliency in New England, Appalachians, and Central Lowlands<br>• Lack of habitat connectivity<br>• Patchy and localized distribution | Projections for 4 remaining AUs based on future scenarios to 2100<br>• Under all 5 plausible scenarios, 3 AUs expected to persist and 1 AU likely extirpated by 2043.<br>• Under 4 plausible scenarios, 4 remaining AUs likely extirpated by 2068; under the positive land management / moderate sea level rise scenario, 1 AU expected to persist and 3 AUs likely extirpated by 2068. |

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# CHAPTER 1 - INTRODUCTION

The eastern black rail (*Laterallus jamaicensis jamaicensis*) is a subspecies of black rail that occurs in salt, brackish, and freshwater wetlands in the eastern United States (east of the Rocky Mountains), Mexico, Central America, and the Caribbean. We, the U.S. Fish and Wildlife Service (Service), were petitioned to list the eastern black rail as endangered or threatened under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) (Act), in April 2010 as a part of the Petition to List 404 Aquatic, Riparian and Wetland Species from the Southeastern United States by the Center for Biological Diversity (Center for Biological Diversity 2010, p. 106). In September 2011, the Service published a 90-day finding that the petition presented substantial scientific or commercial information indicating that listing may be warranted for 374 species, including eastern black rail (76 FR 59836, September 27, 2011). A subsequent notice of violation for not meeting the statutory petition 12-month finding deadline was filed by the Center for Biological Diversity on June 18, 2012. The Service committed to a deadline of September 30, 2018 for submitting to the Federal Register a 12-month finding on eastern black rail. Therefore, a review of the status of the subspecies was initiated to determine if the petitioned action is warranted. Based on the status review, the Service will issue a 12-month finding for the eastern black rail.

We conducted a Species Status Assessment (SSA) to compile the best available data regarding the subspecies' biology and factors that influence the subspecies' viability. The eastern black rail SSA Report is a summary of the information assembled and reviewed by the Service and incorporates the best scientific and commercial data available. This SSA Report documents the results of the status review for the eastern black rail and serves as the biological underpinning of the Service's forthcoming decision (12-month finding) on whether the subspecies warrants protection under the Act.

The SSA framework (USFWS 2016, entire) is intended to be an in-depth review of the subspecies' biology and the factors that affect the subspecies, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The intent is for the SSA Report to be easily updated as new information becomes available and to support all functions of the Service's Ecological Services Program, from Candidate Assessment to Listing to Consultations to Recovery. As such, the SSA Report will be a living document that may be used to inform Endangered Species Act decision making, such as listing, recovery, Section 7, Section 10, and reclassification decisions (the former four decision types are only relevant should the subspecies warrant listing under the Act). Therefore, we have developed this SSA Report to summarize the most relevant information regarding life history, biology, and considerations of current and future risk factors facing the eastern black rail. In addition, we forecasted the possible response of the subspecies to various future risk factors and environmental conditions to formulate a complete risk profile for the eastern black rail.

The objective of this SSA is to thoroughly describe the viability of the eastern black rail based on the best scientific and commercial information available. Through this description, we determined what the subspecies needs to support viable populations, its current condition in terms of those needs, and its forecasted future condition under plausible future scenarios. We took into consideration the likely changes that are happening in the environment – past, current, and future – to help us understand what factors drive the viability of the subspecies.

For the purpose of this assessment, we define **viability** as a description of the ability of a subspecies to sustain populations in the wild over multiple generations through time. Viability is not a specific state, but rather a continuous measure of the likelihood that the subspecies will sustain populations over time (USFWS 2016, entire). Using the SSA framework (Figure 1-1), we consider what the subspecies needs to maintain viability by characterizing the status of the subspecies in terms of its **resiliency**, **representation**, and **redundancy** (USFWS 2016, entire).

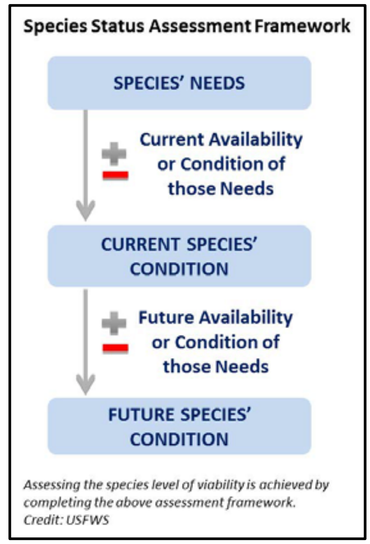


Figure 1-1. Species Status Assessment Framework

- **Resiliency** describes the ability of a population to withstand stochastic disturbance. Stochastic events are those arising from random factors such as weather, flooding, or fire. Resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations. Generally speaking, populations need enough individuals, within habitat patches of adequate area and quality, to maintain survival and reproduction in spite of disturbance. Resiliency is measured using metrics that describe analysis unit condition and habitat; in the case of the eastern black rail, we used occupancy within the analysis units to assess resiliency.

- **Representation** describes the ability of the subspecies to adapt to changing environmental conditions over time. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the subspecies' range. Theoretically, the more representation the subspecies has, the higher its potential of adapting to changes (natural or human caused) in its environment. Because we do not have information related to genetic diversity for the eastern black rail, habitat and latitudinal variability were used to assess representation for the eastern black rail.

- **Redundancy** describes the ability of a subspecies to withstand catastrophic events. A catastrophic event is defined here as a rare, destructive event or episode involving multiple populations and occurring suddenly. Redundancy is about spreading risk among populations, and thus, is assessed by characterizing the number of resilient populations across a species' (or subspecies') range. The more resilient populations the subspecies has, distributed over a larger area, the better chances that the subspecies can withstand catastrophic events. For the eastern black rail, we used the analysis units and their geographic distribution to measure redundancy.

To evaluate the viability of the eastern black rail, we estimated and predicted the current and future condition of the subspecies' in terms of resiliency, representation, and redundancy.

For this SSA, we enlisted the assistance of the Alabama Cooperative Fish and Wildlife Research Unit to analyze available data and to build predictive models to assess current and future status for the eastern black rail. We also relied on supporting SSA core team members, which included Service staff, as well as other biologists from the States or other organizations with specific expertise in the biology and management of the eastern black rail to provide insight on eastern black rail ecology, review technical assumptions of our analysis, assist in constructing future scenarios, and review draft materials.

This SSA Report includes the following chapters:
1. Introduction;
2. Subspecies Biology, Individual Needs, and Range and Distribution. The life history of the subspecies, resource needs of individuals, and the subspecies' historical and current range and distribution;
3. Factors Influencing Viability. A description of likely causal mechanisms, and their relative degree of impact, on the status of the subspecies;
4. Population and Subspecies Needs and Current Condition. A description of what the subspecies needs across its range for viability, and estimates of the subspecies' current condition; and,
5. Future Conditions and Viability. Descriptions of plausible future scenarios, and predictions of their influence, on eastern black rail resiliency, representation, and redundancy.

Cited literature can be found after the final chapter. Additional supplemental information and analysis were used to complete this SSA Report. Information on creating eastern black rail analysis units is presented in Appendix A. Details for the current condition analysis and future projection modeling are described in Appendix B.

This SSA Report provides a thorough assessment of biology and natural history and assesses demographic risks, stressors, and limiting factors in the context of determining the viability and risks of extinction for the eastern black rail. Importantly, this SSA Report does not result in, nor predetermine, any decisions by the Service under the Act. In the case of the eastern black rail, the SSA Report does not determine whether the eastern black rail warrants protections of the Act, or whether it should be proposed for listing as a threatened or endangered species under the Act. The decision whether to propose listing or that listing is not warranted will be made by the

Service after reviewing this document, along with the supporting analysis, any other relevant scientific information, and all applicable laws, regulations, and policies. The results of the decision will be announced in the *Federal Register*, with appropriate opportunities for public input. The contents of this SSA Report provide an objective, scientific review of the available information related to the biological status of the eastern black rail.

## CHAPTER 2 - SUBSPECIES BIOLOGY, INDIVIDUAL NEEDS, RANGE AND DISTRIBUTION

In this chapter, we provide basic biological information about the eastern black rail, including its taxonomic history, morphological description, and known life history. We then outline the resource needs of individuals. Finally we review historical and current information on the range and distribution of the subspecies, including available population estimates.

### 2.1 Taxonomy

The eastern black rail is a subspecies of black rail, a small, cryptic marsh bird. The black rail was first discovered in Jamaica in 1760 as the least water-hen by Browne and Edwards and was formally classified in 1789 by Gmelin (*Rallus jamaicensis*; Allen 1900, entire). No new information was published on the species until 1838 when John James Audubon announced the black rail as a bird of the United States (Audubon 1838, pp. 359-361). Audubon's account was based on specimens taken alive from meadows near Philadelphia, Pennsylvania in 1836 (Allen 1900, pp. 2-3). In addition to the least water-hen, the species also has historically been referred to as the little black rail, little red-eyed crake, and black crake.

The black rail is a member of the family Rallidae (rails, gallinules, and coots) in the order Gruiformes (rails, cranes, and allies; American Ornithologists' Union 1998, p. 130). The family contains 34 genera and 142 species (extant or very recently extinct; Taylor and van Perlo 1998, p. 27). The genus *Laterallus* contains nine species, of which the black rail and Galapagos rail (*L. spilonotus*) form a superspecies (Taylor and van Perlo 1998, p. 220). The eastern black rail is one of four recognized subspecies of black rail and occurs in North America with the subspecies *L. j. coturniculus* (California black rail; Taylor and van Perlo 1998, p. 221; Clements et al. 2016, unpaginated). While the eastern black rail and the California black rail are both found in North America, the subspecies do not co-occur. The two other subspecies of black rail, *L. j. murivagans* and *L. j. salinasi,* occur in South America in Peru, Chile, and Argentina (Taylor and van Perlo 1998 p. 221). The Junín rail (*L. tuerosi*) is sometimes treated as a fifth subspecies (*L. j. tuerosi*; Taylor and van Perlo 1998, p. 220). However, the Service considers the Junín rail to be a discrete species from the black rail based on morphological differences and the Junín rail's restricted range to Lake Junín located in the Peruvian Andes Mountains. (77 FR 43439, July 24, 2012; Dinesen et al. 2017, p. 388). The Junín rail is listed as an endangered species under the Act (77 FR 43439, July 24, 2012).

The American Ornithology Society (AOS; formerly the American Ornithologists' Union) maintains the official taxonomy and nomenclature of birds in North and Middle America, which can be found in the "Checklist of North and Middle American Birds". However, AOS has not included subspecies in the Checklist since 1957 (American Ornithologists' Union 1957, entire) and presently defers to the Birds of North America and Avibase for current treatments of subspecies until AOS can perform a complete taxonomic revision of North American avian subspecies. The Birds of North America and Avibase both currently recognize the eastern black rail (*L. j. jamaicensis*) as a valid subspecies (Eddleman et al. 1994, unpaginated; Avibase 2003, unpaginated). We have no information to suggest there is scientific disagreement about the eastern black rail's taxonomy.

The currently accepted classification of the eastern black rail is:

Class: Aves
Order: Gruiformes
Family: Rallidae
Species: *Laterallus jamaicensis*
Subspecies: *Laterallus jamaicensis jamaicensis*

## 2.2 Subspecies Description

The black rail is the smallest rail in North America. Adults range from 10-15 centimeters (cm) in total length and have a wingspan of 22-28 cm (Eddleman et al. 1994, unpaginated). Eastern black rails weigh 35 grams (g) on average and are larger but have less brightly colored plumage than California black rails (mean mass = 29 g; (Eddleman et al. 1994, unpaginated). Males and females are similar in size and adults are generally pale to blackish gray, with a small blackish bill and bright red eyes (Figure 2-1). The underparts from chin to abdomen are uniformly colored but are lighter on the chin and throat. The nape and upper back are chestnut and the remaining back, uppertail feathers, and remiges (wing flight feathers) are dark gray to blackish with small white spots and sometimes washed with chestnut-brown. The lower abdomen, undertail feathers and flanks are blackish streaked with narrow white and dark gray barring, washed with chestnut. Overall, males are darker and have pale to medium gray throats, while females are lighter and have pale gray to white throats (Davidson 1992a, p. 120; Eddleman et al. 1994, unpaginated). The tarsi (lower legs) and toes are a brownish gray or gray-to blackish-brown (Meanley and Stewart 1960, p. 83; Weske 1969, p. 39).

Figure 2-1. Adult eastern black rail (*Laterallus jamaicensis jamaicensis*). Photo by C. Hand, South Carolina Department of Natural Resources.

Juvenile black rails are similar in appearance to adults, but have duller plumage and fewer and smaller white spots (Bent 1926, p. 329; Eddleman et al. 1994, unpaginated). The white streaking on the flanks is also usually thinner and less apparent. The eyes of juveniles get lighter with age and change from greenish olive or olive green at 4-6 weeks, to amber to hazel at 8 weeks, followed by a rufous, burnt or chrome orange, and lastly, red by about 3 months of age with the pupil remaining black; (Flores and Eddleman 1991 in Eddleman et al. 1994, unpaginated). Black rail chicks are covered in black down with an oily greenish sheen and have dark-gray or dark brownish olive eyes upon hatching (Bent 1926, p. 329; Eddleman et al. 1994, unpaginated). Chicks are only distinguishable from chicks of other rail species by their smaller size and slightly different bill coloration (Eddleman et al. 1994, unpaginated; Hand 2017, pers. comm.). Black rail chick bills are sepia in color and have a 2-5 millimeter (mm)-wide pinkish spot around the nostril (Eddleman et al. 1994, unpaginated). Eggs are smooth and buffy white to pinkish white with evenly distributed, fine, brownish or pale drab spots (Bent 1926, p. 329). The mean dimensions of 157 eastern black rail eggs were 25.99 mm in length (range = 24.43–28.10 mm) and 19.78 mm in breadth (range = 18.86–20.38 mm; Eddleman et al. 1994, unpaginated).

Eastern black rails make multiple vocalizations, but the most commonly heard call is the “kic-kic-kerr” call (Kellogg 1962, p. 699), also known as "kickee-doo" (Robbins et al. 1983 in Davidson 1992a, p. 120) and "ki-ki-krrr" (Weske 1969, p. 16). The call is primarily made by adult territorial males and is the main advertisement call (Davidson 1992a, p. 120). Other calls are “grr” and “churt”, which serve as alarm and contact calls; “grr”, or growling, also is used for territorial defense (Conway 2011, p. 344). The purpose of the “tch” call is unknown, but may be sounded while on the nest; see Conway 2011 (p. 344) for more call names. Male and female eastern black rails have been shown to respond to playback tapes with significantly different vocalizations (Legare et al. 1999, p. 119). Males responded with “kic-kic-kerr”, growling, and “churt”, 48%, 46%, and 6% of the time, respectively, during 91 playback trials; while females responded with the same calls, 5%, 29%, and 65% of the time, respectively, during 43 trials (Legare et al. 1999, pp. 119-120).

There are substantial regional differences in the daily vocalization patterns for eastern black rail (Butler et al. 2015, pp. 10-11). Birds in Maryland predominately call at nighttime from 1-2 hours after sunset to 1-2 hours before sunrise (Weske 1969, p. 17; Reynard 1974, p. 749). Birds in Florida are most vocal at sunset (Legare et al. 1999, p. 122), but will call 1-2 hours before sunset to 1-2 hours after sunrise (Eddleman et al. 1994, unpaginated). In Texas, peak vocalization occurs after sunset until just before midnight followed by a second, smaller peak time within 2 hours of sunrise (Butler et al. 2015, p. 37). The daily vocalization patterns of eastern black rail continue to be an active area of research (Hand 2017b, p. 4; Moore, Tallie 2017, unpublished data).

### 2.3 Life History

In this analysis, we consider the eastern black rail to have four life stages: egg, chick, juvenile, and adult (Figure 2-2). In the following paragraphs, we discuss each of these life stages. This information is summarized in Table 2-1, which shows the annual life cycle of eastern black rail by life stage. When information specific to the eastern black rail was unavailable, we used information from the California black rail (the other subspecies found in the United States) as a supplement.

The egg stage lasts for approximately 26 days (7 days of egg-laying and 19 days of incubation) depending on the clutch size. Adult females lay one egg per day and have an average clutch size of seven eggs (range = 6-8 eggs, $n$ = 16; Legare and Eddleman 2001, p. 173), although clutches as small as four eggs and as large as 13 eggs have been found (Bent 1926, p. 329; Taylor and van Perlo 1998, unpaginated). Both sexes incubate and when one parent is at the nest the other is presumably foraging (Legare and Eddleman 2001, p. 173). The length of the incubation shifts may be equal between sexes; in a telemetry study for California black rail, one male spent 47% of the time incubating and two females spent 43-47% of the time incubating (Flores and Eddleman 1993, p. 84). One of the tracked females appeared to incubate alone, either because she lost her mate or he did not help with incubation, regardless, her nest hatched successfully (Flores and Eddleman 1993, p. 84). Adults may aggressively defend the nest site by raising their wings and charging potential predators (Flores and Eddleman 1993, p. 85).

Eggs are laid in a bowl constructed of live and dead fine-stemmed emergent grasses, rushes, or other herbaceous plant species, often with a canopy and a ramp (Harlow 1913, p. 269; Davidson 1992a, p. 121; Flores and Eddleman 1993, p. 84). Black rail nests are typically well hidden in a dense clump of vegetation over moist soil or shallow water (Harlow 1913, p. 269; Flores and Eddleman 1993, pp. 83-84). In Florida, 17 nests were built over mud or moist soil, mean nest height above the substrate was 6.0 cm (SD = 2.3 cm), and mean bowl diameter was 6.8 cm (SD = 1.1 cm; Legare and Eddleman 2001, p. 173). Information on the reproductive success of eastern black rail is limited; however, in the same Florida study, nest success was 43% and daily nest survival probability was 0.968 (Mayfield method; Legare and Eddleman 2001, p. 174). Nest failure was caused by flooding from heavy rainfall ($n$ = 4) and by predation by small mammals and fire ants (*Solenopsis invicta*; $n$ = 2) (Legare and Eddleman 2001, p. 174). Repeated renesting following nest failure is a common behavior in marsh birds (Marshall and Reinert 1990, p. 507; Armistead 2001, p. 249), and eastern black rails have been shown to have successful replacement clutches (Legare and Eddleman 2001, p. 175). There also is evidence of pairs having two successful nests in a season (double brooding; Hand 2017, unpublished data); however, whether or not double brooding is common is unknown. Eastern black rail egg-laying and incubation primarily occur from May to August with some early nesting in March and April (Table 2-1; Watts 2016, p. 10-11; Moore and Wilson 2018, unpublished data).

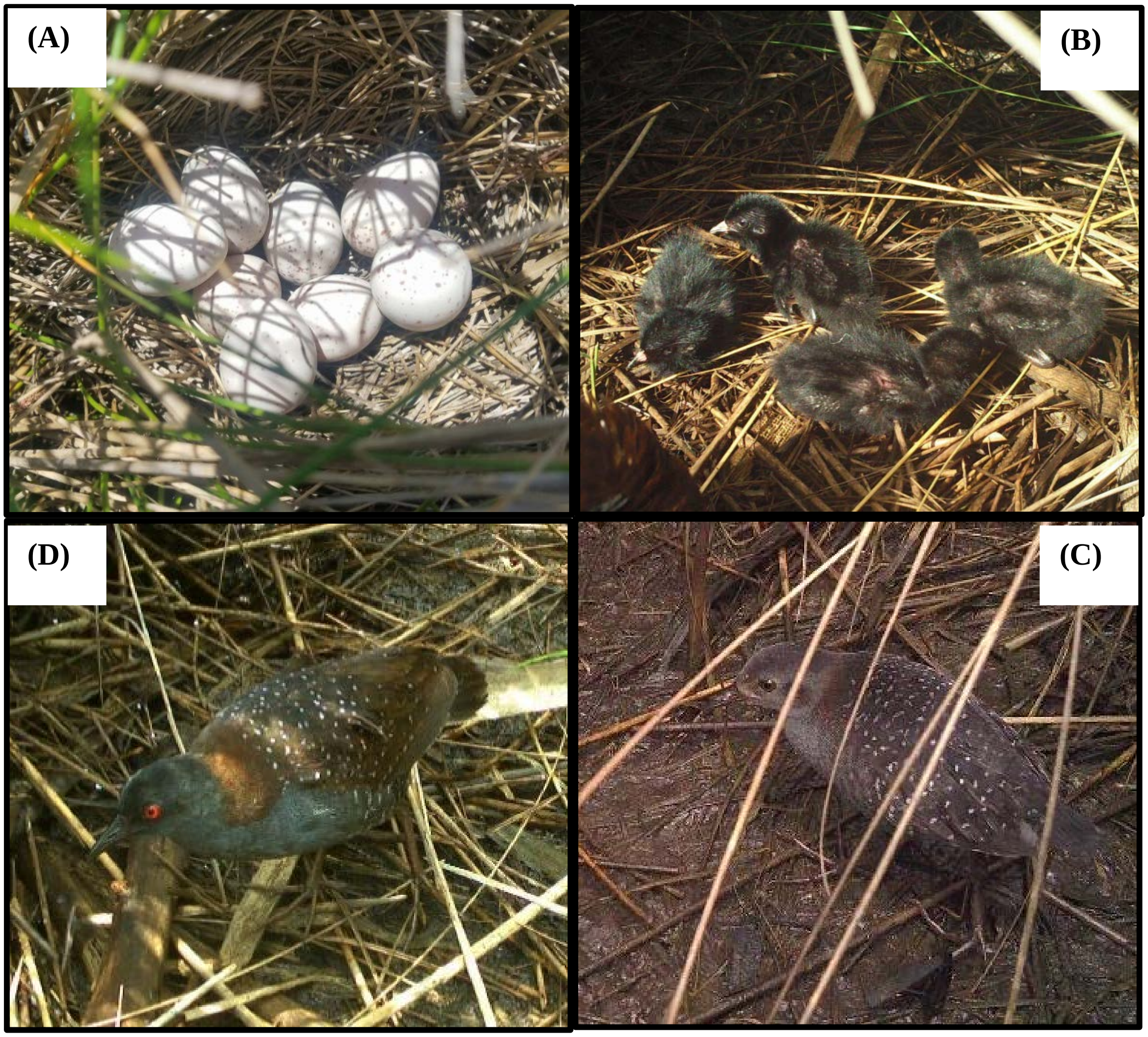


Figure 2-2. Eastern black rail (*Laterallus jamaicensis jamaicensis*) nest with eggs (A), chicks (B), juvenile (C), and adult (D). Photos by K. Schumacher, Fort Hays State University (A; Kansas) and C. Hand, South Carolina Department of Natural Resources (B, C, D; South Carolina).

Once an egg hatches, the chick stage begins and lasts for approximately 1.5 months until the chick enters the juvenile stage. Hatching is synchronous and chicks remain in the nest until all eggs have hatched (Davidson 1992a, p. 121; Flores and Eddleman 1993, p. 86). The downy chicks are precocial and typically leave the nest within 24 hours of hatching (Davidson 1992a, p. 121), but stay with the parents in the area of the parental territory and often return to the nest site to roost for the evening (Flores and Eddleman 1993, p. 86). Chicks are brooded at least for the first few days and are fed bill-to-bill by both parents, but sometimes only the female; brood division may occur for foraging and brooding (Figure 2-3; Taylor and van Perlo 1998, p. 223; Hand 2017a, p. 7). The chick stage occurs from May through September (Table 2-1).

Information on the timing of fledging is limited; however, in a population in South Carolina, chicks fledged as early as mid-June and as late as late September (Hand 2017a, p. 8).

Figure 2-3. Parental care in the eastern black rail (*Laterallus jamaicensis jamaicensis*). Photos by C. Hand, South Carolina Department of Natural Resources.

There is minimal information on the growth and development of black rails (Eddleman et al. 1994, unpaginated); however, a 2017 study in South Carolina recently developed the first known timeline of chick aging and development for the eastern subspecies (Hand 2017a, pp. 6-8). The chick stage lasts for approximately 42 days (6 weeks) and begins on Day 0 with chicks hatching in the nest in their natal down (Eddleman et al. 1994, unpaginated; Hand 2017a, p. 6). On Day 4, the bill is pinkish with a dark tip and egg tooth, legs are short and thick, and wings are tiny. Chicks continue to be brooded by either adult, stay close together, and may open wings for balance or as a begging display. On Day 7, the egg tooth is gone, the black pupil is distinguishable, but legs remain short and thick and wings are very small relative to the body. On Day 14, legs become longer and thinner and contour feathers and remiges begin to emerge. By Day 28, the bill is almost completely blackish, legs are nearly full size, contour feathers are visible in all tracts, and individuals are slightly smaller than adults in size. By Day 42, chicks have obtained juvenile plumage and are capable of flight (fledge). Timing is approximate and may be refined with more information; see Hand 2017a (entire) for more details on the growth and development of eastern black rail chicks.

The juvenile stage begins when a chick has fledged and is independent from the parents. Juveniles undergo a partial postjuvenile (also known as pre-formative or first pre-basic) molt, and obtain immature plumage by approximately 3 months of age (Taylor and van Perlo 1998, pp. 220-221; Pyle 2008, p. 477). This molt takes place between June and November on the breeding grounds (timing inferred from Hand 2017a, p. 8; Table 2-1). A partial first prebreeding (or first pre-alternate) molt takes place prior to the breeding season between February and April of the following calendar year (Taylor and van Perlo 1998, p. 221). The juvenile stage may last up to

10.5 months, until an individual obtains its first breeding plumage and becomes sexually mature at approximately 1 year of age (Eddleman et al. 1994, unpaginated).

There is little additional information on juvenile behavior and growth; however, it is believed that juveniles disperse widely from the breeding areas and may appear in locations where no typical habitat is present as evidenced by strikes with man-made structures (Eddleman et al. 1994, unpaginated). Of eight strike records for the black rail species, six individuals were confirmed as juveniles and two of the juveniles were the eastern subspecies (Browne and Post 1972, entire; Eddleman et al. 1994, unpaginated). Long-distance dispersal (>100 km) also has been shown in the California black rail using modern genetic and isotopic marker techniques, although the vast majority of birds (95.6%) were classified as residents (Hall and Beissinger 2017, pp. 208, 216). Experts surmise that juvenile eastern black rails (and California black rails) are likely capable of colonizing appropriate habitat relatively quickly (Flores and Eddleman 1991, pp. 25, 27; Eddleman et al. 1994, unpaginated).

Eastern black rails reach the adult life stage the spring after hatch year once sexually mature. Adults presumably breed each year and are probably monogamous (Taylor and van Perlo 1998, p. 223). As mentioned previously, pairs may re-nest after nest failure and/or have double broods, although, double brooding may be infrequent (Legare and Eddleman 2001, p. 175; Hand 2017, unpublished data). Adults undergo a complete post breeding molt (also known as a definitive pre-basic molt) each year between July and September on the breeding grounds (Table 2-1; Pyle 2008, p. 477; Hand 2017b, p. 15). Individuals simultaneously lose all of their remiges (wing flight feathers) and rectrices (tail flight feathers), and are temporarily unable to fly for approximately 3 weeks (Figure 2-4; Flores and Eddleman 1991, pp. iii, 62-63; Eddleman et al. 1994, unpaginated). California black rails experienced a drop in body weight during this time, indicating that the metabolic costs of performing a complete molt may outweigh an individual's ability to replenish energy reserves (Flores and Eddleman 1991, p. 62). Therefore, black rails are particularly vulnerable during this period of flightlessness and lower body weight (Flores and Eddleman 1991, p. 63). Information on molt prior to the breeding season is limited; observations, also for California black rail, suggest that most adults undergo a partial pre-breeding (pre-alternate) molt between February and April (Flores and Eddleman 1991, p. iii). However, there was no evidence of this molt in eastern black rails during recent banding efforts (January – May) in Texas (Moore and Wilson 2017, unpublished data).

Breeding eastern black rails are territorial, but the extent and nature of this behavior is poorly known due to birds frequently shifting call sites over a short time period as well as ceasing to call when nesting begins (Weske 1969, p. 24). Calling birds also have a tendency to have a clumped distribution (Kerlinger and Wiedner 1990 in Taylor and van Perlo 1998, p. 223). An early estimate of home range measured from recaptures and vocalizations during the breeding season was 3.24 hectares (ha) for an eastern black rail in a tidal salt marsh in Maryland (Weske 1969, pp. 25, 33). In a study in Florida also during the breeding season, males had significantly larger home ranges than females ($p = 0.0024$); mean home range size for males ($n = 9$) was 1.3 ha (SD = 0.52, range = 0.82–3.1 ha) and for females ($n = 6$) it was 0.62 ha (SD = 0.27, range = 0.51–0.86 ha) (Legare and Eddleman 2001, p. 173). Radio-telemetry was only performed during the egg-laying and incubation stages, so the home ranges estimated in the study may be smaller than annual home ranges (Legare and Eddleman 2001, p. 174). Other rail species commonly use larger areas outside of the incubation period/breeding season (Bookhout and Stenzel 1987, p. 445; Conway et al. 1993, p. 287). However, in a recent telemetry study for eastern black rails during the winter season in Texas, the average home range was 0.67 ha ($n = 7$ [6 males and 1 female]), approximately half the size of the average home range for males in the Florida study (Moore et al. 2018, p. 20). Home ranges for the California black rail in Arizona were not significantly different between seasons and averaged 0.5 ha or less ($n = 31$), although birds' core areas (areas of concentrated use) were generally smaller during the nesting season (Flores and Eddleman 1991, pp. ii, 21-22). Birds actively use and defend the core area in their home range and outside the core area less so (Flores and Eddleman 1991, p. 25). Site fidelity is unknown for the eastern black rail, but California black rails in the Arizona study had high site fidelity with their home range centers shifting significantly at 10 meters ($p = 0.04$), but not at 20 meters ($p = 0.11$) between seasons (Flores and Eddleman 1991, pp. ii, 21).

Figure 2-4. Adult eastern black rails (*Laterallus jamaicensis jamaicensis*) simultaneously lose all of their remiges (wing flight feathers) and rectrices (tail flight feathers), as indicated by the arrows, and are temporarily unable to fly during their postbreeding (definitive pre-basic) molt. Photos by C. Hand, South Carolina Department of Natural Resources.

The nature of migration for the subspecies is poorly understood. Preliminary results using stable isotopes suggest there are two populations of eastern black rail in the south central United States: a migratory population breeding in Colorado and Kansas and wintering in Texas, and a non-migratory year-round population in Texas (Butler 2017, pers. comm.). Additionally, it is suspected that the more northerly portion of the Atlantic coast population found in the United

States migrates and winters further south on the Atlantic coast (e.g., the Carolinas and Florida) and also in the Caribbean and Central America (Eddleman et al. 1994, unpaginated; Taylor and van Perlo 1998, p. 221-222). Birds are occasionally detected as far north as New Jersey during the winter on the Atlantic coast (Root 1988 in Eddleman et al. 1994, unpaginated). Based on communication tower mortality data, birds migrate at night along a broad front from mid-March to early May in the springtime and from early September to early November in the fall (Table 2-1; Cooke 1914, pp. 33-34; Stoddard 1962, p. 49; Browne and Post 1972, p. 491; Watts 2016, p. 11). The fall peak appears to be mid-September to mid-October (Eddleman et al. 1994, unpaginated; Watts 2016, p. 11). The spatial distribution of communication towers from these data indicates there are no apparent concentrated routes for either spring or fall migration (Eddleman et al. 1994, unpaginated). See Section 2.5 for a discussion of the eastern black rail's current and historical range and distribution.

The species' lifespan is not known. One male California black rail (*L. j. coturniculus*) in Arizona was at least 2.5 years old (Flores and Eddleman 1991, p. iii). Patuxent Wildlife Research Center has no banding return data to estimate longevity for the species (Bird Banding Laboratory 2017, unpaginated). Banding return data for the only rail species in the database is 7 years 6 months for a clapper rail banded after hatch year and then harvested (Bird Banding Laboratory 2017, unpaginated). Clapper rails are significantly larger than eastern black rails and likely have a longer lifespan; mass ranges from 199-400 g for clapper rails compared to an average 35 g for eastern black rails (Eddleman et al. 1994, unpaginated; Rush et al. 2018, unpaginated).

Table 2-1. The annual life cycle of eastern black rail (*Laterallus jamaicensis jamaicensis*) by life stage. Lighter colored shading indicates off-peak times (i.e., when life history events may occur, but are outside the timing of the majority of known records); mos = months of age. Sources: Cooke 1914, p. 33-34; Ehrlich et al. 1988, p. 102; Davidson 1992a, p. 121; Flores and Eddleman 1993, p. 84, 86; Eddleman et al. 1994, unpaginated; Taylor and van Perlo 1998, p. 220-223; Legare and Eddleman 2001, p. 173-174; Hand 2017a, p. 8; Wilson 2017, pers. comm.

| Life Stage | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Egg** | | | Laying & Incubation (26 days) | | | | | | | | | |
| **Chick** | | | | | Parental Care | | | | | | | |
| | | | | | | Molt (by 1.5 mos) | | | | | | |
| **Juvenile** | | Molt (by ~12 mos) | | | | | Molt (by ~3 mos) | | | | | |
| | | | | | | | | Dispersal?* | | | | |
| **Adult** | | | Mating | | | | | | | | | |
| | | | Laying & Incubation (26 days) | | | | | | | | | |
| | | | | | Parental Care | | | | | | | |
| | | | Molt?* | | | | | Molt (flightless) | | | | |
| | | | Migration† | | | | | | Mig.† | | | |
| | Wintering | | | | | | | | | Wintering | | |

General note: This table provides the overall approximate timing of life history events for the eastern black rail. A latitudinal gradient exists regarding the timing of events given the large geographic range of the subspecies, but is not detailed here.
*Dispersal: specific timing of juvenile dispersal is unknown. Molt: it is unknown if eastern black rails undergo a partial pre-breeding molt in the spring; this molt is observed in the California black rail subspecies.
†Not all individuals migrate.

## 2.4 Resource Needs (Habitat) of Individuals and Habitat Description

This section summarizes what is known about the resource (habitat) needs for the eastern black rail. Compared to other bird species, the black rail, including the eastern black rail subspecies, is one of the least understood birds primarily due to the species' cryptic nature, the limitations of making direct observations, and difficulties capturing and monitoring the species.

### *2.4.1 Resource Needs*

Eastern black rails occupy relatively high elevations along heavily vegetated wetland gradients, with soils moist or flooded to a shallow depth (Eddleman et al. 1988, p. 463; Nadeau and Conway 2015, p. 292). Occupied habitats are reflective of the subspecies' movement habits. Eastern black rails fly little during the breeding and wintering seasons, and will typically flush only for a short distance when pursued (Bent 1926, pp. 329-330). Instead, the birds will remain on the ground, running quickly through dense vegetation likely using the runways of rodents and rabbits (e.g., *Microtus* spp.) (Armistead 2001, p. 247; Taylor and van Perlo 1998, p. 223), and are considered secretive because of this behavior. Because black rails require dense vegetative cover that allows movement underneath the canopy (Table 2-2), and because birds are found in a variety of salt, brackish, and freshwater marsh habitats that can be tidally or non-tidally influenced, plant structure is considered more important than plant species composition in predicting habitat suitability (Flores and Eddleman 1995, pp. 357, 362). Occupied habitat tends to be primarily composed of fine-stemmed emergent plants (rushes, grasses, and sedges) with high stem densities and dense canopy cover (Flores and Eddleman 1995, p. 362; Legare and Eddleman 2001, pp. 173-174). Vegetation height is generally ≤1 meter (m) in coastal habitats, but taller in occupied cattail and bulrush marshes (Davidson 1992a, pp. 120, 126-127; Legare and Eddleman 2001, p. 170; Culver and Lemly 2013, pp. 316-318). However, when shrub densities become too high, the habitat becomes less suitable for eastern black rails. Soils are moist to saturated (occasionally dry) and interspersed with or adjacent to very shallow water (1-6 cm; Table 2-2) (Legare and Eddleman 2001, pp. 173, 175).

As stated previously, eggs need a nest bowl constructed of live and dead fine-stemmed emergent, herbaceous plants (Harlow 1913, p. 269; Davidson 1992a, p. 121; Flores and Eddleman 1993, p. 84). Nests must be well hidden in a dense clump of vegetation over moist soil or shallow water to provide shelter from the elements and protection from predators (Table 2-2) (Harlow 1913, p. 269; Flores and Eddleman 1993, pp. 83-84). Flooding is a frequent cause of nest failure for eastern black rails; therefore, water levels must be lower than nests during egg-laying and incubation in order for nests to be successful (Table 2-2) (Legare and Eddleman 2001, p. 175). Mean nest height data from Florida for 17 nests was 6.0 cm; SD = 2.3 cm (Legare and Eddleman 2001, p. 173). In addition, if water depth exceeds ~2.5 cm chicks would have to swim during brood rearing and risk their down becoming waterlogged. Therefore, shallow pools that are 1-3 cm deep may be the most optimal for foraging and for chick-rearing (Hand 2017, pers. comm.).

Despite this narrow requirement, some elevational variability in the substrate is required. The birds require elevated refugia with dense cover to survive high water events due to the propensity of juvenile and adult black rails to walk and run rather than fly and chicks' inability to fly (Table 2-2). During extreme flooding events black rails may also face increased predation when birds are forced from their usual dense cover (Evens and Page 1986, entire).

Table 2-2. Resource needs (habitat) for eastern black rail (*Laterallus jamaicensis jamaicensis*) to complete each life stage.

| Life Stage | Resources Needs (Habitat) | References |
|---|---|---|
| **Egg** | • Nest well hidden in a dense clump of vegetation over moist soil or very shallow water (between 1-6 cm*)<br>• Water level lower than nest height | Davidson 1992a, p. 121.<br>Flores and Eddleman 1993, p. 84-86.<br>Legare and Eddleman 2001, p. 170, 173-175.<br>Taylor and van Perlo 1998, p. 222. |
| **Chick / Juvenile / Adult** | • Moist to saturated substrates (occasionally dry) interspersed with or adjacent to very shallow water (between 1-6 cm)<br>• Dense herbaceous vegetation that provides cover<br>• Elevated refugia to escape high water events<br>• Food – small (<1 cm) aquatic/terrestrial invertebrates, seeds | Davidson 1992a, p. 121-122.<br>Eddleman et al. 1994, unpaginated.<br>Ehrlich et al. 1988, p. 102.<br>Flores and Eddleman 1993, p. 83-86.<br>Hands et al. 1989, p. 1.<br>Legare and Eddleman 2001, p. 170, 173-175.<br>Taylor and van Perlo 1998, p. 222-223. |

*Range suggested from available data.

High primary production in wetland ecosystems, especially in tidal marshes, provides an abundance of food resources (Greenberg 2006, p. 3). Eastern black rails forage on a variety of small (<1 cm) aquatic and terrestrial invertebrates, especially insects, and seeds (e.g., *Typha, Scirpus*, *Spartina spp.*) by gleaning or pecking at individual items (Table 2-2) (Ehrlich et al. 1988, p. 102; Eddleman et al. 1994, unpaginated). The stomach contents of an eastern black rail in Maryland contained larval and adult aquatic beetles (3 genera of Hydrophilidae [water scavenger beetles]) and a Curculionidae species (true weevils; Spangler 1959 in Davidson 1992a, p. 122). The stomachs of two birds taken in Florida in June and December and one bird from New Jersey in May contained 98-100% animal matter that was mostly insects (Weske 1969, p. 34). Black rails are probably opportunistic foragers and changes in diet in winter are likely related to lower invertebrate availability and greater energy provided by seeds (Flores and Eddleman 1991, p. 36).

### *2.4.2 Habitat Vegetation Associations*

Eastern black rail habitat can be tidally or non-tidally influenced, and range in salinity from salt to brackish to fresh. Vegetation associations are different between habitats in the interior portion of the range and those associated with the coastal areas of the contiguous United States. Vegetation nomenclature largely follows the Integrated Taxonomic Information System (ITIS 2018, unpaginated). Coastal marshes of the Atlantic Coast vary from those of the Gulf Coast in tidal regime. Atlantic Coast tides are approximately four times greater in amplitude than those of the Gulf Coast, and vary less diurnally (Kunza and Pennings 2008, p. 674). As a result, the plant community structure varies between the two coasts, with greater plant species diversity found in the Gulf Coast (Kunza and Pennings 2008, pp. 674, 680). Dominant cover plants present within salt marshes also vary along the Atlantic Coast and the Gulf Coast. For these reasons, species-habitat associations of the eastern black rail vary by location.

In the northeastern United States, the eastern black rail is typically found in Atlantic Coast salt and brackish marshes, with dense cover of salt meadow cordgrass (*Spartina patens*); smooth cordgrass (*S. alterniflora*); big cordgrass (*S. cynosuroides*); coastal saltgrass (*Distichlis spicata*); black needlerush (*Juncus roemerianus*); blackgrass (*J. gerardii*); and chairmaker's bulrush (*Schoenoplectus americanus*). Birds may also occupy the more upland extents of these marshes, which include shrubs such as Jesuit's bark (*Iva frutescens*) and eastern baccharis (*Baccharis halimifolia*), and the invasive common reed (*Phragmites australis*). Wet meadows and freshwater marshes of cattail (*Typha angustifolia*) and bulrush (*Scirpus fluviatilis*) also are occupied (Davidson 1992b, p. 4). Further south on the Atlantic coast in the southeastern United States, breeding habitat includes managed and unimpounded salt and brackish marshes and saline emergent wetlands. While salt meadow cordgrass and coastal saltgrass dominate the high marsh in the northeast United States, sand cordgrass (*Spartina bakeri*) begins to dominate in South Carolina (Schmalzer et al. 1991, p. 68). In coastal South Carolina, dominant vegetation includes sand cordgrass, salt meadow cordgrass, chairmaker's bulrush, black needlerush, eastern baccharis, sturdy bulrush (*Schoenoplectus robustus*), and cattails (*Typha spp.*) (Figure 2-5; Roach and Barrett 2015, pp. 1067, 1073).

From the Florida Gulf Coast and panhandle west to the Pearl River in Mississippi, black needlerush is the dominant plant species (Mendelssohn et al. 2017, p. 452). In Florida Gulf Coast marshes, habitat occupied by eastern black rails is comprised of black needlerush and limited elevational bands supporting *Spartina* spp. and possibly eastern baccharis inland and adjacent to these marshes (Florida Fish and Wildlife Conservation Commission 2003, unpaginated). Breeding habitat at Florida's Big Bend (Gulf Coast) and at St. Johns National Wildlife Refuge (NWR) (Atlantic side) includes plant species such as black needlerush, coastal saltgrass, saltwater false willow (*B. angustifolia*), sand cordgrass, wax myrtle (*Myrica cerifera*), and Jamaica swamp sawgrass (*Cladium jamaicense*) (Legare and Eddleman 2001, p. 171). Nests are constructed on or in a range of plants, including: sand cordgrass, salt meadow cordgrass, Jamaica swamp sawgrass, and black needlerush. Nests are also constructed in a combination of sand cordgrass or salt meadow cordgrass and other species, including saltmarsh fimbrystylis (*Fimbristylis castanea*), saltmarsh morning glory (*Ipomoea sagittata*), climbing hempvine (*Mikania scandens*), hairawn muhly (*Muhlenbergia capillaris*), knotroot bristlegrass (*Setaria geniculata*), bluestem (*Andropogon* spp.), star grass (*Dichromena* spp.), and rosy camphorweed (*Pluchea rosea*) (Legare and Eddleman 2001, p. 173).

Also on the Gulf Coast, in Texas coastal salt marshes, eastern black rails occupy high elevation zones dominated by gulf cordgrass (*S. spartinae*) and salt meadow cordgrass which may be accompanied by shrub species such as eastern baccharis (*B. halimifolia*) or Jesuit's bark (Figure 2-5; Tolliver 2017, pp. 27-28). Impounded intermediate marshes of the Gulf Coast Chenier Plain of Louisiana and Texas are typified by dominance of salt meadow cordgrass (Gabrey et al. 2001, p. 220), while unimpounded intermediate marshes include both salt meadow cordgrass and gulf cordgrass. Unimpounded intermediate marshes occur in the Texas Mid-Coast, with salt meadow cordgrass and gulf cordgrass again appearing as dominants (Enwright et al. 2014, p. 2). See Watts 2016 (p. 139) for a list of primary vegetation referenced in black rail accounts for coastal states.

In the interior United States, such as in Oklahoma, eastern black rails utilize wet sedge meadows with dense coverage of sedges and cattails (Beck and Patten 2007, p. 8). In Kansas grasslands, eastern black rails were found occupying wet meadows dominated by spikerushes (*Eleocharis* spp.) with some use of cattails and bulrushes (*Schoenoplectus* spp.) (Figure 2-5; Kane 2011, p. 24). Eastern black rails use shallow wetlands in Colorado dominated by cattails, hardstem bulrush (*Scirpus acutus var. acutus*), soft-stemmed bulrush (*Schoenoplectus tabernaemontani*), and willow (*Salix* spp.) in the overstory (Griese et al. 1980, p. 96). In Colorado's most recent Breeding Bird Atlas, eastern black rails were detected exclusively in extensive cattail marshes with standing water (Wickersham 2016, p. 188). Suitable habitat has dense or thick emergent vegetation with high vegetation density (interspersion) as well as a mixture of new and residual growth (Colorado Parks and Wildlife 2016, pp. 2-3).


Figure 2-5. Examples of eastern black rail (*Laterallus jamaicensis jamaicensis*) habitat from South Carolina (A), Texas (B), Kansas (C), and Honduras (D). Photos by C. Hand, South Carolina Department of Natural Resources (A); J. Woodrow, U.S. Fish & Wildlife Service (B); R. Laubhan, U.S. Fish & Wildlife Service (C); and R. Gallardo and A. Vallely, private (D).

Detections of eastern black rails outside the United States are highly limited (see Section 2.5); however, descriptions of occupied habitat are available for a few locations. In Panama, calling birds and a nest were discovered in an open savanna that contained a number of knolls (small hills) (Harty 1964, p. 20). The nest was found in a depression located at the base of a knoll and was made from various fine-stemmed plants that were approximately 76 cm in height: a species of narrow-leaved grass (*Paspalum* spp.), a beak-rush or wide-leaved sedge (*Rhynchospora* spp.), and a small amount of an unidentified wide-leaved grass (Harty 1964, p. 20). During the breeding season in Belize, birds were found in a savanna composed of 25-50 cm tall vegetation dominated by Cuban dropseed (*Sporobolus cubensis*), grand paspalum (*Paspalum pulchellum*), *Mesosetum filifolium*, and the beak-rush sedges *Rhynchospora globose*, and *R. holoschoenoides* (no nests were found; Russell 1966, p. 105). In terms of woody vegetation, chaparro (*Curatella americana*) and nanze (*Byrsonima crassifolia*) were scattered in the savanna as well as a few clusters of oaks (*Quercus oleoides*) no taller than 76 cm (Russell 1966, p. 105). Caribbean pine (*Pinus caribea)* surrounded the open savanna (Russell 1966, p. 105). The savanna was typically wet for most of the year with average annual rainfall of over 355.6 cm (140 inches), although February to May tended to be drier (Russell 1966, p. 105). A recent detection of an eastern black rail in Honduras occurred in partially flooded grassland over 100 ha (247 acres [ac]) that also was bordered by Caribbean pine (Figure 2-5; Vallely and Gallardo 2013, p. 320).

There is less information for eastern black rail habitat in the winter range, but wintering habitat is presumably similar to breeding habitat since some sites in the southern portion of the breeding range are occupied year round. In these areas, overwintering birds may overlap with the breeding population (Watts 2016, p. 10). Little is known about eastern black rails during migration, including migratory stopover habitat (Eddleman et al. 1994, unpaginated). Again, habitat during migration is presumed to be similar to breeding habitat; however, individuals also seem to appear more frequently in wet prairies, wet meadows, or hay fields during migration (Todd 1977 in Eddleman et al. 1994, unpaginated).

## 2.5 Historical and Current Range and Distribution

The eastern black rail occupies portions of the eastern United States (east of the Rocky Mountains), Mexico, Central America, and the Caribbean. Individuals that are presumed to be the eastern subspecies have also been reported on occasion in Brazil.

### *2.5.1 Contiguous United States*

#### <u>2.5.1.1 Overview</u>

In the United States, eastern black rails are found in both coastal and interior areas, but the majority of detections are from coastal sites (Figure 2-6). In a recent assessment of 23 states that comprise the primary area of the subspecies’ range within the contiguous United States (i.e., along the Atlantic and Gulf Coasts), approximately 90% of documented breeding-season occurrence records occurred at coastal locations (Watts 2016, p. 117). Interior records accounted for less than 10% of total occurrences and over 60% of the interior records occurred before 1950 (Watts 2016, p. 117). Interior areas are undersampled compared to coastal habitats and expanding survey networks to include more interior habitats is a research priority. However, interior records have always been relatively uncommon throughout the subspecies’ documented occurrence history in the United States (1836-2016; Watts 2016, p. 117) when compared to the relative frequency and quantity of coastal occurrence records during the same time frame. The 2016 “coastal” assessment of 23 states reviewed 150 years of literature, museum specimens, eBird records with supporting information, and results from targeted black rail surveys to evaluate the historical and current status and distribution of the eastern black rail along the Atlantic and Gulf Coasts of the United States (Watts 2016, entire). The assessment covers a large area of the subspecies' range, both geographically and in terms of the areas presumed to support the highest abundances of eastern black rails, and is the most comprehensive treatment of the subspecies completed to date (Watts 2016, entire). Readers are referred to this assessment for more details and state-by-state treatments of the history of eastern black rail in the 23 states along the Atlantic and Gulf Coasts of the contiguous United States (Watts 2016, entire).

A similar assessment was completed in 2012 for an additional 15 states in the interior United States where eastern black rail has been found: Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Oklahoma, Ohio, New Mexico, South Dakota, and Wisconsin (Smith-Patten and Patten 2012, entire). The 2012 “interior” assessment also included California and Arizona, which support the California black rail subspecies and not the eastern black rail subspecies. Published and unpublished literature, museum specimens, and audio recordings were reviewed to document the occurrence history of eastern black rail in each state (Smith-Patten and Patten 2012, p. 3). The assessment identified eastern black rail breeding populations under differing degrees of certainty (i.e., confirmed, probable, and possible) in three of the 15 interior states (Smith-Patten and Patten 2016, p. 2); see Section 2.5.1.2 below for further discussion. Similar to the coastal assessment described above, the interior assessment covers a large portion of the subspecies' range in terms of geography; however, the states treated in the interior assessment are collectively not presumed to support a high abundance of eastern black rails historically or currently, relative to the Atlantic and Gulf Coast states. Eastern black rails are considered rare and local inland (in the interior), from Colorado east to Connecticut, as there have been few breeding records and few sites are occupied consistently (Eddleman et al. 1994, unpaginated). Readers are referred to this assessment for more details and state-by-state treatments of the history of eastern black rail in the 23 states along the Atlantic and Gulf Coasts of the United States (Watts 2016, entire).

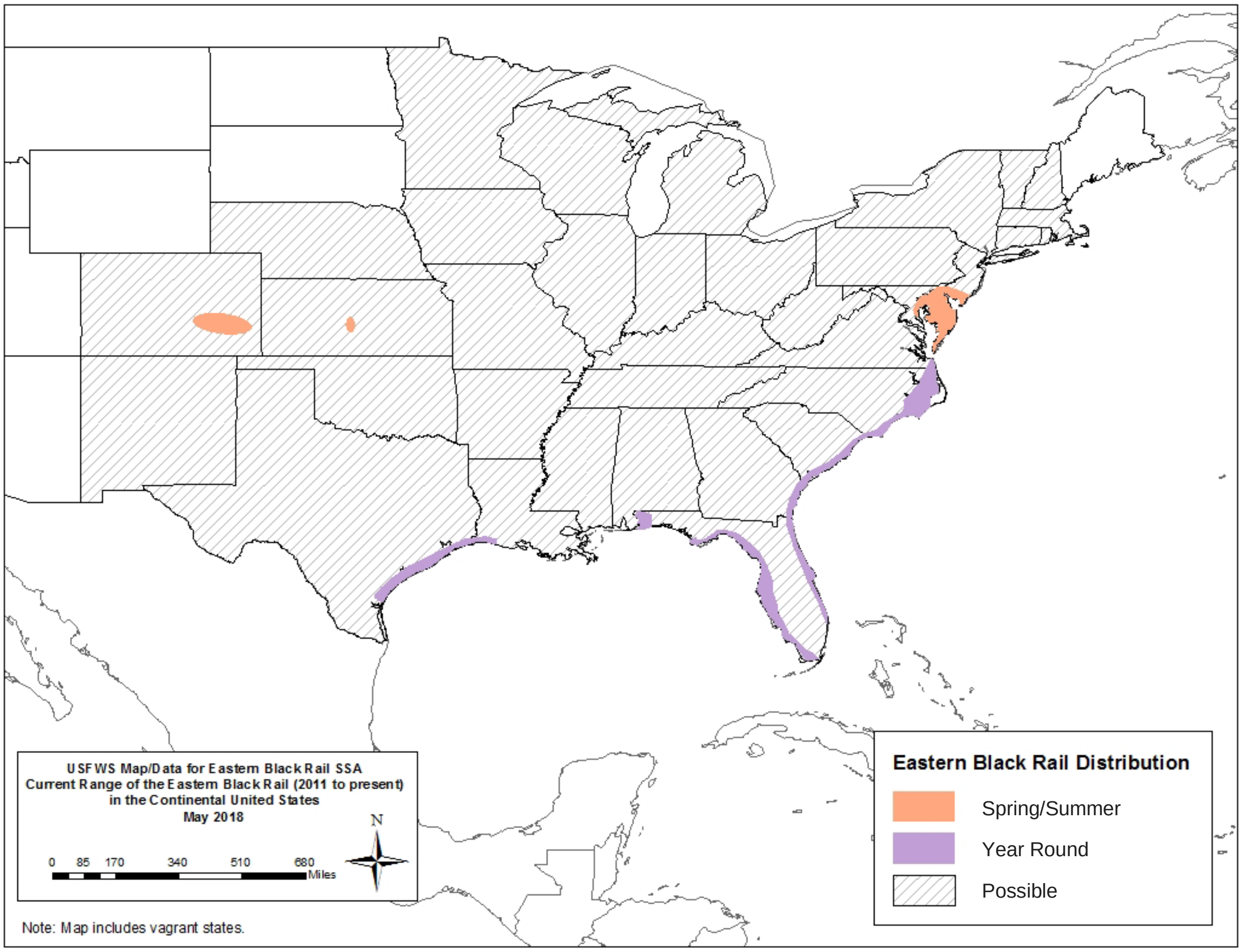


Figure 2-6. Current range of the eastern black rail (*Laterallus jamaicensis jamaicensis*) in the contiguous United States based on our present understanding of the subspecies' distribution. The shaded areas show where eastern black rails are known to primarily occur; however, because suitable habitat is not uniformly distributed across the landscape, birds also are not evenly distributed. Birds may be detected outside of the shaded areas as indicated by the gray hatching; individuals may or may not be considered vagrants depending on the location. Entire states are hatched for simplicity since eastern black rail occurrence outside of the shaded areas is poorly known. References: Eddleman et al. 1994, unpaginated (shaded areas), and Smith-Patten and Patten 2012, entire; Watts 2016, entire; and eBird 2017, unpaginated (hatched areas).

### 2.5.1.2 Range and Distribution

For the purposes of this SSA, we considered records prior to 2011 to represent historical records of the subspecies, and records from 2011-2017 to represent current records. This is consistent with the treatment of records in the coastal assessment (Watts 2016, p. 15, 17). The cutoff between historical (prior to 2011) and recent (2011 and later) records was based on a substantial increase in surveys specifically for eastern black rail as well as a noticeable increase in the use of eBird (Watts 2017, pers. comm.).

Within the northeastern United States, historical (1836-2010) records document the eastern black rail as present during breeding months from Virginia to Massachusetts, with 70% of historical observations (773 records) in Maryland, Delaware, and New Jersey (Watts 2016, p. 22). The latter three states are considered historical strongholds for eastern black rail in this region of the United States (the Northeast) as well as across the subspecies' entire breeding range (Watts 2016, p. 22), due to the total number and frequency of observations reported over time. Virginia, New York, and Connecticut account for an additional 21% of the historical records (235 records) from the Northeast (Watts 2016, p. 22). Recent (2011-2016) records from the Northeast are low in number (64 records) and almost all records were restricted to outer coastal habitats (Figure 2-7; Watts 2016, pp. 22, 24). The distribution of the recent records points toward a substantial contraction in the subspecies' range southward of approximately 450 kilometers (280 miles), with vacated historical sites from 33 counties generally occurring from the Newbury marshes in Massachusetts to Ocean County, New Jersey (Figure 2-7; Watts 2016, pp. 24, 119). Further, the distribution of the recent records has become patchy along the coast and an evaluation of the records within the 15 counties still currently occupied suggests an almost full collapse of the eastern black rail population in the Northeast (Watts 2016, p. 24). Based on a population estimate from 2016, New Jersey is believed to support the highest abundance of eastern black rails remaining in the Northeast with an estimated 40-60 breeding pairs (see Section 2.5.1.3; Watts 2016, p. 19).

In the Chesapeake Bay region, the distribution of eastern black rail has contracted and the counts of birds have declined. A series of systematic surveys for eastern black rails has been conducted around the Bay since the early 1990s (Watts 2016, pp. 59, 67). Surveys estimated 140 individuals in the 1990-1992 survey period to 24 individuals in 2007 down to eight individuals in 2014, a decline of over 90% in less than 25 years (Watts 2016, p. 59; Brinker 2014, unpublished data). Of 328 points surveyed in Virginia in 2007, 15 birds were detected; a second round of surveys in 2014 yielded two detections, equating to an 85% decline over seven years (Watts 2016, pp. 67, 71). In addition, for one of the historical strongholds within the Chesapeake Bay, Elliott Island, high decadal counts have declined from the hundreds in the 1950s to the single digits in recent years (Table 2-3; Watts 2016, p. 61).

Table 2-3. High counts of eastern black rails on Elliott Island, Maryland. Adapted from Watts 2016, p. 61.

| Decade/Year | High Counts of Eastern Black Rail |
|---|---|
| 1950s | 100+ |
| 1960s | 40 |
| 1970s | 45 |
| 1980s | 47 |
| 1990s | 44 |
| 2000s | 12 |
| 2010 | 2 |
| 2012-2015 | 1 |
| 2016 | 0 |

The eastern black rail was historically present during breeding months at inland and coastal locations throughout southeastern coastal states (the Southeast; Figures 2-6 and 2-7); this region includes North Carolina, South Carolina, Georgia, Florida, Tennessee, Mississippi, Alabama, Louisiana, and Texas (Watts 2016, pp. 75-76). Of these states, Texas, Florida, South Carolina, and North Carolina contained 89% of all historical observations (734 records) in the Southeast (Watts 2016, p. 77). The other states (Georgia, Tennessee, Mississippi, Alabama, and Louisiana) either do not have a history of supporting eastern black rails consistently or are considered to be on the peripheries of known breeding areas (Watts 2016, p. 77). There were 108 recent records of eastern black rails during the breeding season and at a coarse view, the same southeastern states that substantially supported the subspecies historically still support the subspecies at present (Texas, Florida, South Carolina, and North Carolina; Figure 2-7; Watts 2016, pp. 77, 79). However, North Carolina presently shows a severe decline in the number of occupied sites with four properties occupied in 2014-2015, down from nine in 1992-1993 (Watts 2016, p. 80). Additional surveys in 2017 yielded no new occupied sites in coastal North Carolina (Watts and Smith 2017, unpublished data). The decline is apparent at Cedar Island NWR, the historical stronghold in the state, where high counts of eastern black rails have declined over the past 50 years from 80+ birds in the 1970s, to 20 in the 1980s, five in the 1990s, and one in the 2000s and one again in 2016 (Watts 2016, p. 80). South Carolina shows a limited distribution with two known occupied areas and an estimated 50-100 breeding pairs, leaving Texas and Florida as the current strongholds for the Southeast (Figure 2-7, see Section 2.5.1.3). At the time of the coastal assessment it was surmised that coastal Georgia may support an unknown breeding population; however, a coast-wide survey in 2017 at 409 survey points yielded no detections of eastern black rails (Watts and Smith 2017, unpublished data). Across the Atlantic and Gulf Coasts, recent observations show poor presence inland and a widespread reduction in the number of utilized sites across coastal habitats (Watts 2016, p. 79).

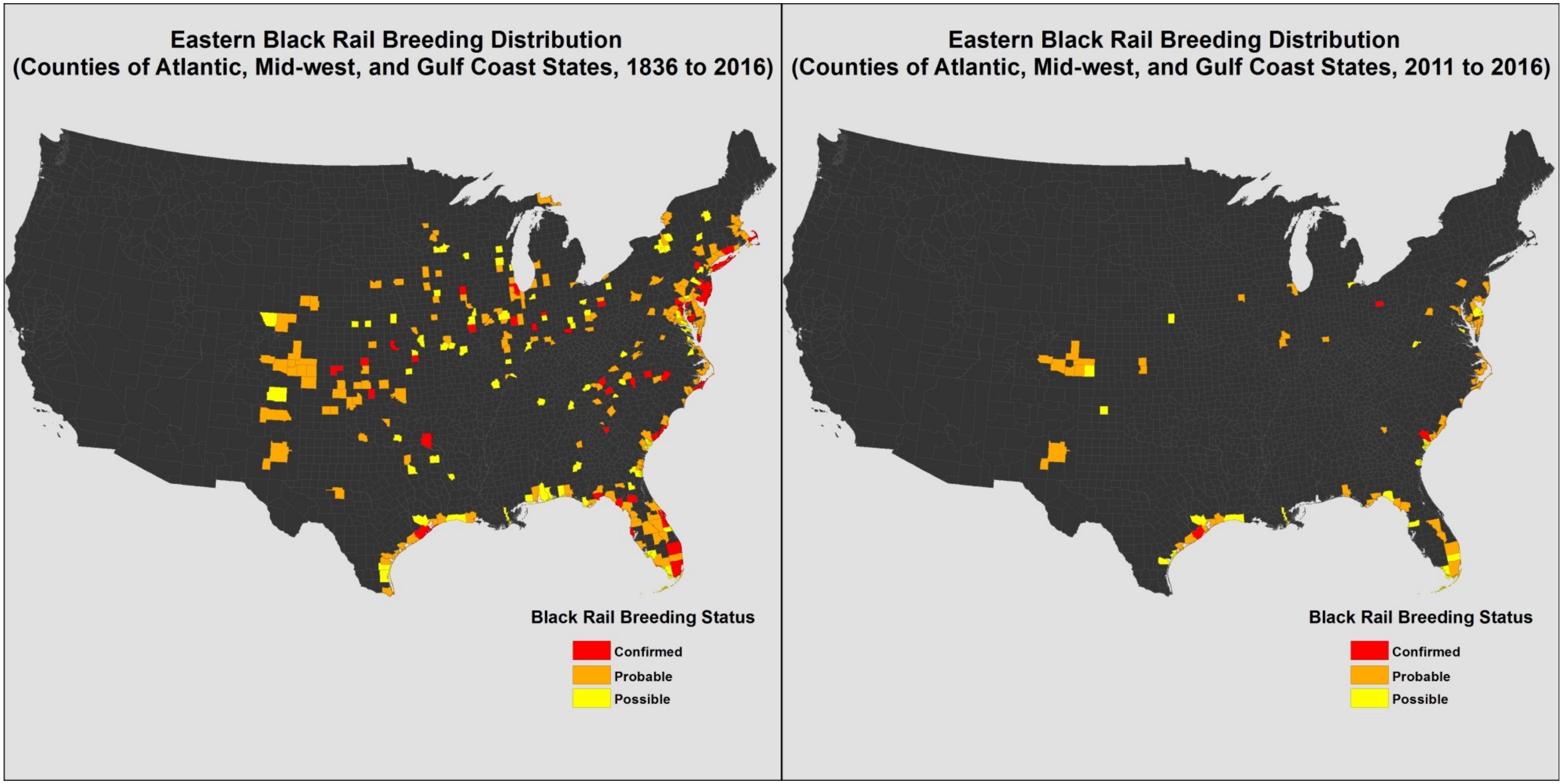


Figure 2-7. A map of counties with credible records of eastern black rail (*Laterallus jamaicensis jamaicensis*) during the breeding season (1 April through 31 August) in the contiguous United States. Historical and recent (1836-2016) records are shown on the left and recent records only (2011-2016) are shown on the right. Black rail breeding status: confirmed – record of a nest with eggs or young observed, probable – record occurred between 15 May and 31 August, possible – record occurred between 1 April and 15 May (Watts 2016, p. 10). See Watts 2016 (entire) for methodology and a full assessment of eastern black rail in Atlantic and Gulf Coast states. Maps provided by Watts (2018, unpublished data).

The history of the subspecies' distribution in the interior contiguous United States is poorly known. Historical literature indicates a wide range of interior states were occupied by eastern black rail, either regularly or as vagrants (Smith-Patten and Patten 2012, entire). Bent 1926 (pp. 331-332) listed eastern black rail detections in Kansas, Iowa, Minnesota, Illinois, Wisconsin, and Ohio (and "probably southern Ontario"). The American Ornithologists' Union also reported breeding in Indiana and migrant (or summer) records in Colorado, Nebraska, Oklahoma, Missouri, and Michigan (1957, p. 158). Direct evidence of historical nesting (i.e., eggs, chicks, or juveniles) in the interior states is primarily limited to records from 1936 and prior (Hands et al. 1989, p. 3; Smith-Patten and Patten 2012, entire).

Presently, eastern black rails are reliably located within the Arkansas River Valley of Colorado (presumed breeder in the state), and in southcentral Kansas in Stafford, Finney, Franklin, Barton, and Riley counties (confirmed breeder in the state) (Smith-Patten and Patten 2012, pp. 9, 17; Butler et al. 2014, p. 20). In Colorado, the subspecies is encountered in spring and summer at Fort Lyon Wildlife Area, Bent's Old Fort and Oxbox State Wildlife Area, Bristol, and John Martin Reservoir State Park (Smith-Patten and Patten 2012, p. 10). In Kansas, eastern black rails are regularly present during the breeding months at Quivira NWR and Cheyenne Bottoms Wildlife Area (Smith-Patten and Patten 2012, p. 17), and at Cheyenne Bottoms Preserve during wet years when habitat conditions are suitable (Penner 2017, pers. comm.). In Oklahoma, occurrence mapping suggests that this subspecies had at a minimum a patchy historical distribution throughout the state. Counties with sighting records from 1915 to 1977 include Alfalfa, Beaver, Cleveland, Greer, Johnson, Noble, and Osage. To date, the most direct evidence of breeding in Oklahoma, apart from the seasonality of confirmed occurrence records, is from a 1971 photograph of a juvenile bird at Salt Plains NWR in Alfalfa County (Beck and Patten 2007, pp. 8-9). It is possible that there is not sufficient suitable habitat or numbers of birds to constitute a true breeding population of eastern black rails in Oklahoma (Smith-Patten and Patten 2018, p. 7). However, future surveys in Oklahoma may discover additional suitable habitat that supports an isolated breeding population as appears to be the case in Colorado and Kansas (Smith-Patten and Patten 2018, p. 7).

The 2012 interior assessment concluded that eastern black rails are currently vagrants (casual or accidental vagrants) in Arkansas, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, New Mexico, Ohio, South Dakota, and Wisconsin (Smith-Patten and Patten 2012, entire). Some of these states have conducted marshbird surveys following the 2012 assessment, which have yielded few additional detections of eastern black rails. For example, marshbird surveys to document the subspecies in Nebraska, where the bird has been identified as a rare spring and fall migrant statewide (Sharpe et al. 2001, p. 145; Johnsgard 2013, p. 49), suggest that the bird's occurrence in the state is still very uncommon. Surveys in 2016 documented a single vocalizing eastern black rail during the breeding season in Clay County, Nebraska (McGregor et al. 2016, p. 134). While the eastern black rail was determined to be an accidental vagrant in

South Dakota in the 2012 interior assessment (Smith-Patten and Patten 2012, p. 29), the single accepted record for the state has since been rejected by the South Dakota Rare Bird Records Committee; therefore, South Dakota Game, Fish, and Parks continue to not have any verified occurrence records of the subspecies in the state (Dowd Stukel 2017, pers. comm.). Given the difficulty in detecting eastern black rails and the annual or ephemeral nature of its suitable habitat in the interior states, it is possible the actual presence or absence of eastern black rails in these states is obscured; however, the best available data indicate the bird is a vagrant through most of the interior states with small populations in both Kansas and Colorado.

#### 2.5.1.3 Population Estimates

As stated above, there was a 2016 "coastal" assessment of eastern black rail for 23 states to evaluate the historical and current status and distribution along the Atlantic and Gulf Coasts of the United States (Watts 2016, entire), and this was the most comprehensive treatment of the subspecies completed to date. Prior to this assessment, the lack of status information for eastern black rails within the breeding range has precluded defining population estimates for the subspecies (Watts 2016, p. 118). A global population estimate, that included all known areas in North America, Central America, and the Caribbean, of 25,000 to 100,000 individuals was provided by Wetlands International in 2012 based on a workshop assessment; however, experts believe this global estimate was optimistically high given the eastern black rail population within the study area for the coastal assessment is the largest known (Watts 2016, p. 118). In 2013, population estimates (reported as number of breeding pairs) for the Atlantic and Gulf Coasts of the United States were determined by research biologists based on local expertise at two black rail workshops (Table 2-4; Wilson et al. 2013, unpublished data). Biologists from federal and state governments and non-governmental organizations participated in the workshops. In 2016, the population estimates derived from the 2013 workshops were reassessed by the Center for Conservation Biology following a more thorough assessment of existing occurrence information and recent survey data (Table 2-4; Watts 2016, entire). The total population estimate for eastern black rail in Atlantic and Gulf Coast states was revised from 945 – 2,250 breeding pairs in 2013 to 455 – 1,315 breeding pairs in 2016 (Table 2-4).

Table 2-4. Population estimates reported as number of breeding pairs for eastern black rail (*Laterallus jamaicensis jamaicensis*) in the northeast and southeast United States. Level of uncertainty refers to the 2016 estimate. Table modified from Watts 2016, p. 19.

| | **Population Estimate (# of breeding pairs)*** | | **Uncertainty**[†] |
|---|---|---|---|
| **Geographic Area** | **2013** | **2016** | |
| Maine | 0 | 0 | Low |
| New Hampshire | 0 | 0 | Low |
| Vermont | 0 | 0 | Low |
| Massachusetts | 0 | 0 | Moderate |
| Rhode Island | 0 | 0 | Low |
| Connecticut | 0 | 0 | Low |
| New York | 0 | 0 | Moderate |
| Pennsylvania | 0 | 0-5 | Low |
| New Jersey | 25-50 | 40-60 | Moderate |
| Delaware | 25-50 | 0-10 | Moderate |
| Maryland | 200-250 | 15-30 | Moderate |
| District of Columbia | 0 | 0 | Low |
| West Virginia | 0 | 0 | Low |
| Virginia | 20-50 | 0-10 | Moderate |
| **Northeast Region** | **270-400** | **55-115** | |
| North Carolina | 50-100 | 40-60 | Moderate |
| South Carolina | 100-200 | 50-100 | Low |
| Tennessee | 0 | 0 | Low |
| Georgia | 25-50 | 10-40 | High |
| Florida | 200-500 | 200-500 | High |
| Alabama | 0 | 0 | Low |
| Mississippi | 0 | 0 | Low |
| Louisiana | 0 | 0-10 | High |
| Texas | 300-1,000 | 100-500 | High |
| **Southeast Region** | **675-1,850** | **400-1,200** | |
| **Total Study Area** | **945-2,250** | **455-1,315** | |

*Population estimates for 2013 were estimated by research biologists based on local expertise at two black rail workshops (Wilson et al. 2013, unpublished data). Population estimates were reassessed in 2016 by the Center for Conservation Biology following a more thorough assessment of existing occurrence information and recent survey data (Watts 2016, entire).

[†]Uncertainty was a qualitative assessment by the Center for Conservation Biology. If geographic voids in coverage were large within a state, uncertainty in the distribution and population estimate was considered to be high. If coverage of habitat was complete or nearly so, uncertainty was considered low.

In Texas, a separate study was performed to understand occupancy, distribution, and abundance of eastern black rails along the Texas Coast (Tolliver et al. 2017, p. entire). For two survey years, researchers conducted repeat point count surveys at 308 points spread across six study sites in order to estimate the area occupied and abundance of eastern black rails (Tolliver et al. 2017, pp. 6, 13). For 2015, the total number of estimated hectares occupied was 16,725 ha (95% Confidence

Interval [CI] = 12,791 – 20,658 ha), and the total number of eastern black rails over the six study sites was 1,526 birds (95% CI = 354 – 5,830 birds); for 2016, the total number of hectares occupied was 17,055 ha (95% CI = 12,444 – 21,665 ha) with the total number of black rails estimated to be 1,299 birds (95% CI = 329 – 5,316 birds) (Tolliver et al. 2017, p. 18). In 2017, extensive flooding from Hurricane Harvey impacted sites of documented occupancy across the entire Texas coast during August and September when adult eastern black rails are undergoing a period of flightlessness from their post-breeding molt (Table 2-1). While there were no direct observations of eastern black rail mortality, high numbers of dead Virginia rails were found in storm wrack at one site (Sullivan 2018, pers. comm.). Formal surveys by Texas State University – San Marcos staff for the 2018 winter season at San Bernard NWR began in January 2018. Although early in the field season, initial observations suggest a reduced presence of the subspecies at previously occupied sites (Wilson 2018, pers. comm.).

Formal breeding season surveys for eastern black rail in Colorado are currently underway (spring 2018) for the first time and information is forthcoming (Rossi 2018, pers. comm.). Expert opinion, eBird records, and the Colorado Breeding Bird Atlas II have so far documented at least five counties in the State within the Arkansas River Basin where more than 100 vocalizing males occur in any given year during the breeding season (across counties) (Colorado Bird Atlas Partnership 2016, p. 188; Colorado Parks and Wildlife 2016, p. 1; eBird 2017, unpaginated; Rossi 2017, pers. comm.). No population estimates for eastern black rail are available for Kansas or Oklahoma. Based on available eBird data, the highest count of eastern black rails recorded in a day at Quivira NWR in Kansas was five birds in 2017 (eBird 2017, unpaginated). For Oklahoma, between 1999 and 2017, detections of at least 19 individuals were made in Beaver, Ellis, McCurtain, Tillman, Texas, and Woodward counties (Beck and Patten 2007, p. 6; Smith-Patten and Patten 2018, pp. 18-19).

### *2.5.2 Caribbean, Central America, and Brazil*

The eastern black rail has been reported to occur throughout the Caribbean and Central America and it has been hypothesized that some birds may migrate from the coastal United States to the Caribbean in the winter; however, its distribution is poorly understood (Figure 2-8; Taylor and van Perlo 1998, pp. 221-222. There have been very few reports of eastern black rails in recent years from the Caribbean and Central America. This may be due to lack of survey effort, as well as loss of habitat and predation.

Historically, the eastern black rail may have bred in Puerto Rico. However, the bird is now considered very rare and local, occurring mainly from October to March (Raffaele et al. 2003, p. 58), suggesting that the bird is an overwintering resident. The two most recent detections of eastern black rail in Puerto Rico are from March 2001 at the Laguna Cartagena NWR and October 2007 at Puerto Mosquito, adjacent to Vieques NWR (Lewis 2001, unpaginated; Gemmill 2007, unpaginated). The 2007 sighting of the eastern black rail occurred during a year of high water levels (Gemmill 2016, pers. comm.). Suitable habitat for eastern black rails does occur on the Refuge, but surveys are intermittent (Barandiaran 2016, pers. comm.; Gemmill 2016, pers. comm.). Researchers did not find any eastern black rails during January 2012 or January 2014 surveys in Puerto Rico (Schaffner 2016, pers. comm.; Beissinger 2018, pers. comm.).

Eastern black rail is considered a rare non-breeding resident in Cuba (Raffaele et al. 2003, p. 58). An October-November 2014 study in Cuba recorded eastern black rail calls on eight days, although the bird was never seen (Mitchell 2016, pers. comm.). Similarly, a black rail call was heard during a Caribbean Conservation Trust bird survey in 2016, although the bird was never seen (Doyle 2016, unpaginated). While a breeding population has been speculated to exist on Cuba, recent claims of singing birds (and year-round birds) are undocumented (Mitchell 2016, pers. comm.). The eastern black rail has been reported as a rare and local breeding resident on Hispaniola, but the subspecies is not currently reported on the island (Dod 1986, p. 196; Raffaele et al. 2003, p. 58; Gonzales Pantaleón 2017, pers. comm.). We have no current information on the bird in Jamaica. The historical resident population of eastern black rails in Jamaica is now considered very rare and local (Raffaele et al. 2003, p. 58), and possibly extinct, due to predation from the non-native mongoose (Taylor and van Perlo 1998, p. 222; Hume and Walter 2012, p. 88). Black rails are also considered very rare and local in the Bahamas and a vagrant elsewhere in the West Indies (Raffaele et al. 2003, p. 58).

In Central America, the eastern black rail is considered a rare resident in Belize (Russell 1966, p.105). The subspecies has been detected in five of the six districts in the country (all districts except Corozal) and there are three main wetlands where the bird may be a resident (Martinez 2017, pers. comm.). A breeding season record of one male exists from Veracruz, Mexico (Dickerman and Warner 1961, p. 339); however, no recent occurrences have been documented in the country (Rivera Téllez, 2017). The bird was historically present in Costa Rica based on limited records, but the current status is unknown; there are no nesting records and no recent records (Stiles et al. 1989, pp. 126-127; Garrigues and Dean 2007, p. 56). One record of a flushed bird and nest exists from Panama from 1963; there are no recent records (Ridgely and Gwynne Jr. 1989, p. 120). Early records (mid-1800s) document eastern black rails in Guatemala, but there are no other records from the country (Vallely and Gallardo 2013, p. 319). In June 2013, researchers recorded an adult eastern black rail in partially flooded grassland habitat in eastern Honduras (Vallely and Gallardo 2013, p. 320). Additional individuals have been detected along the Mosquito Coast in Honduras since the 2013 record (Gallardo 2018, pers. comm.); however, the extent of their presence is unknown.

Historically, there is one record of eastern black rail from Brazil (Taylor and van Perlo 1998, p. 221), with several recent eBird reports from northern Brazil (Lees 2013, unpaginated; Cerqueira 2015, unpaginated; Dantas 2015, unpaginated, unpaginated; Davis 2017, unpaginated). These are sporadic sightings and no country-wide surveys have been undertaken to our knowledge. All recent sightings have been of adult eastern black rails; there are no reports of nests, chicks, or juveniles.

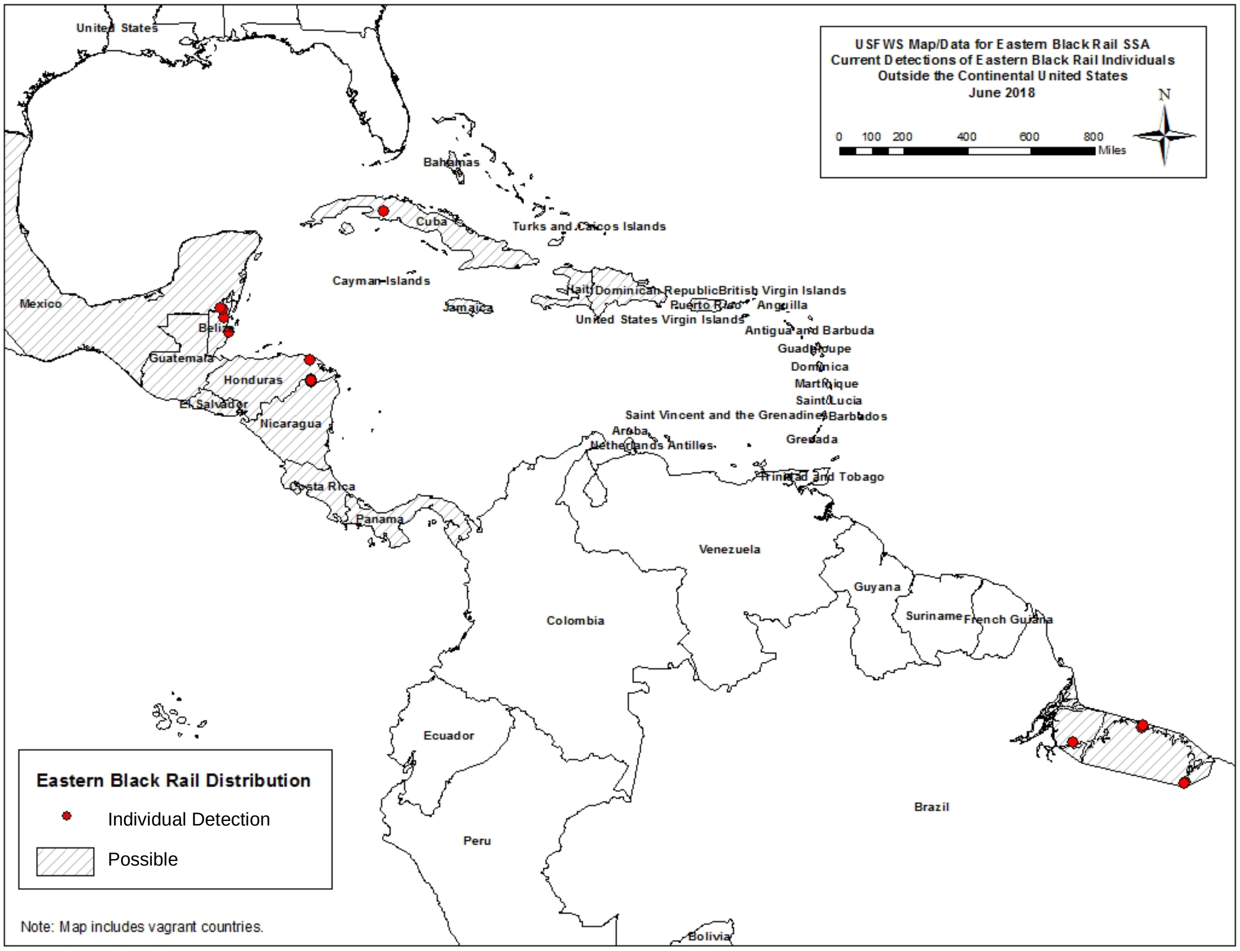

Figure 2-8. Current records (2011 to present) of eastern black rail individuals (*Laterallus jamaicensis jamaicensis*) in the Caribbean, Central America, and Brazil. Red circles are known individual records of eastern black rails outside of the contiguous United States that were available at the time of the Eastern Black Rail Species Status Assessment (SSA). Birds may be detected outside of the areas of individual records as indicated by the gray hatching. Eastern black rail occurrence outside of the contiguous United States is poorly known and individuals may or may not be considered vagrants depending on the location. Hatching is generally based on Taylor and van Perlo 1998, p. 221. Eastern black rail record references: Vallely and Gallardo 2013, p. 319 and eBird 2017, unpaginated.

### *2.5.3 Summary of Range and Population Estimates*

The northeastern, southeastern, and interior United States differ in the quantity and quality of survey data available for the eastern black rail. However, when viewing historical occurrences on the state level compared to what is known of present distribution, the range contraction and site abandonment noted by Watts 2016 (p. 79) appear to be present throughout the coastal eastern United States. In relative terms, regional strongholds still exist for this subspecies; however, the best available scientific data suggest that the remaining strongholds support a relatively small total population size across the contiguous United States, i.e., an estimated 1,299 individuals on the upper Texas coast within protected areas prior to Hurricane Harvey, and an estimated 355 – 815 breeding pairs on the Atlantic Coast from New Jersey to Florida (including the Gulf Coast of Florida). Given that we do not have consistent monitoring or survey results for the eastern black rail throughout the Caribbean and Central America, it is likely birds occur throughout this region, but we have no information to indicate that the bird is present in large numbers.

# CHAPTER 3 – FACTORS INFLUENCING VIABILITY

The following discussion provides a summary of the past, current, and future factors that are affecting or could be affecting the current and future condition of the eastern black rail throughout some or all of its range. Risks that are not known or suspected to have effects on eastern black rail populations, such as overutilization for commercial and scientific purposes, are not discussed in this SSA report.

## 3.1 Habitat Fragmentation and Conversion

The eastern black rail is a wetland dependent bird requiring dense emergent cover and extremely shallow water depths (< 6 cm) over a portion of the wetland-upland interface to support its resource needs. While specific information is lacking regarding the amount of this habitat that is available, there are general status and trend information for wetlands within the range of the eastern black rail. There is less information regarding the status of grasslands over the range, however, there are some general trends available.

Grasslands and their associated palustrine (freshwater) and estuarine wetland habitats have experienced significant loss and conversion since European settlement (Hannah et al. 1995, pp. 137, 151; Noss et al. 1995, pp. 57-76, 80-84; Bryer et al. 2000, p. 232). Approximately 50% (greater than 100 million ac) of the wetlands in the conterminous United States have been lost over the past 200 years (Dahl 1990, entire). The primary cause of this loss was conversion for agricultural purposes (Dahl 1990, p. 9). Wetland losses for the states within the eastern black rail's historical range were from 9% to 90%, with a mean of 52% (Dahl 1990, p. 6). Similarly, most of the native grassland/prairie habitats associated with eastern black rail habitat have been lost since European settlement (Sampson and Knopf 1994, pp. 418-421).

This dramatic falling trend has decreased with recognition of the benefits of wetland habitats and subsequent increasing conservation and regulatory measures. This was especially true for estuarine wetlands. However, despite regulatory efforts to minimize the loss of wetland habitats, losses and alterations continue to occur to habitats occupied by the eastern black rail. Marshes continue to face substantial impacts from dikes, impoundments, canals, altered freshwater inflows, erosion, relative sea level rise, tidal barriers, tropical storm events and other natural and human-induced factors (Turner 1990, entire; Kennish 2001, entire; Adam 2002, entire; Tiner 2003, p. 513; Gedan et al. 2009, entire).

There are a variety of status and trend reports available regarding wetlands (USFWS 2017a, unpaginated); however, different categories and time periods make exact comparisons over time somewhat limited. A summary of these reports for the conterminous United States are provided in Table 3-1. These data show that while conservation measures to protect wetlands have shown meaningful decreases in wetland habitat loss, there remain significant losses of emergent wetlands through the most recent report period.

Table 3-1. Emergent wetland gains and losses by specific time period as reported in Status and Trend Reports for the Conterminous United States. Sources: Frayer et al. 1983, p. 22; Tiner 1984, pp. 31-32; Dahl and Johnson 1991, pp. 9-10; Dahl 2000, pp. 29-31; Dahl 2006, pp. 49, 72; and Dahl 2011, pp. 38, 46, 59-60.

| Time Period | Estuarine Emergent hectares (acres) | Palustrine Emergent hectares (acres) |
|---|---|---|
| mid-1950s to mid-1970s | -150,543 (-372,000) | -1,092,651 (-2,700,000) |
| mid-1970s to mid-1980s | -28,733 (-71,000) | 89,031 (222,000) |
| 1986 to 1997 | -5,868 (-14,500) | -488,050 (-1,206,000) |
| 1998 to 2004 | -13,436 (-33,200) | -57,720 (-142,570) |
| 2004 to 2009 | -45,140 (-111,500) | 108,3754 (267,800) |

There are two additional status and trend reports for coastal watersheds that cover a significant portion of the eastern black rail range where most of the occurrences are documented (Table 3-2) (Stedman and Dahl 2008, p. 19; Dahl and Stedman 2013, p. 24; Watts 2016, entire). We note that there are differences between these reports and the Status and Trends reports listed in Table 3-1; these studies used somewhat different methods and datasets.

Table 3-2. Area gains and losses (hectares [acres] and %) for wetlands in Atlantic and Gulf of Mexico coastal watersheds of the United States (Stedman and Dahl, 2008 pp. 19, 22; Dahl and Stedman 2013, pp. 24, 28).

| Time Period | Wetland Type | Atlantic Coast | | Gulf Coast | |
|---|---|---|---|---|---|
| | | hectares (acres) | % | hectares (acres) | % |
| 1998 – 2004 | Estuarine Emergent | -7,458 (-18,430) | -1.0 | -17,843 (-44,090) | -1.8 |
| | Palustrine Emergent | -4,302 (-10,630) | -0.6 | -20,101 (-49,670) | -1.8 |
| 2004 – 2009 | Estuarine Emergent | -2,979 (7,362) | -0.4 | -48,884 (-120,796) | -5.2 |
| | Palustrine Emergent | 17,650 (43,614) | 2.3 | -824 (-2,035) | -0.1 |

The most recent status and trends report indicates that estuarine emergent wetland losses are mostly attributable to conversion to open water through erosion (Dahl and Stedman 2013, p. 37) while freshwater emergent wetland losses appear to be the result of development (Dahl and Stedman 2013, p. 35).

In some locations, loss of salt marsh associated with conversion to open water due to sea level rise is being offset to some extent by salt marshes becoming established in areas where salt water intrusion occurs also due to sea level rise. Although this does not mean such shifts could continue indefinitely (i.e., into the longer term), it does illustrate a possible outcome in the near-term in some areas, depending on a variety of relevant local conditions. An example of this habitat shift has been described occurring in the Chesapeake Bay (Schieder et al. 2017, entire). In addition, possible landward migration of salt marshes on the U.S. Gulf Coast has been described, along with potential barriers to such migration (Enwright et al. 2016, pp. 311-314).

These emergent wetland gains due to landward expansion of sea level can be hampered by barriers to wetland migration such as roads, levees, canals, and other social infrastructure. One limit to salt marsh movement is referred to as the "coastal squeeze" problem, which refers to natural and/or human-created barriers which limit salt marshes from becoming established in new areas as relative sea level rises. This includes natural barriers (e.g., topographic features), existing barriers related to human actions (e.g., shoreline rip-rap, hardened surfaces) intended to be protective barriers for coastal human communities or infrastructure, and future physical barriers being considered as part of future efforts to reduce the effects of sea level rise (Torio and Chmura 2013, entire; Armitage et al. 2015, entire; Enwright et al. 2016, entire; White and Kaplan 2017, entire).

There are some regional/state trends and studies for emergent wetland habitats across the range of the eastern black rail. In the south central plains, playa lakes (ephemeral, shallow lakes) are a prominent landscape feature and important to maintaining biological diversity (Bolen et al. 1989, pp. 615-619). Playa lakes are scattered across the south central plains landscape (Colorado, Kansas, New Mexico, Oklahoma, and Texas), however they have been radically altered by human activity (Bolen et al. 1989, pp. 619-621; Tsai et al. 2007, p. 690; Tsai et al. 2010, pp. 1112-1115; Johnson et al. 2012, pp. 275, 278, 282) with less than 0.2% remaining relatively intact and as much as 60% or 16,555 playas having disappeared (Johnson et al. 2012, p. 282). Historically, these lakes represented ephemeral emergent wetland habitat and were used by wetland dependent wildlife species (Bolen et al. 1989, pp. 615-619), and may have been used by eastern black rail.

Emergent wetland losses on the Texas Coastal Plain between 1955 and 1992 included a 29% loss of palustrine emergent wetlands and an 8.2% loss of estuarine emergent wetlands for a combined loss of over 260,000 acres (Moulton et al. 1997, p. 13). Most of these losses are the result of conversion for agricultural production. Overall status and trends for Florida wetlands show significant annual average net wetland loss between 1954 and 1974 of 74,000 ac per year, 26,000 ac of loss per year between 1974 and 1984, and 5,000 ac of loss per year between 1984 and 1996 (Dahl 2005, p. 34). Vegetated estuarine wetlands (including shrubs such as mangrove habitats) in Florida increased by 4,000 ac between 1985 and 1996 while freshwater emergent wetlands declined by 260,000 ac in the same time period (Dahl 2005, p. 35). Wetland trends in South

Carolina showed losses of estuarine vegetated wetlands of 274 ac and palustrine emergent wetlands of 2,214 ac between 1982 and 1989 (Dahl 1999, p. 41). This wetland loss to upland rate in South Carolina was a reduction of approximately 48% in the annual rate of wetland loss from previous reports (Dahl 1999, p. 44).

Geographically isolated freshwater emergent wetlands have been associated with supporting eastern black rails. Summaries of this wetland type across the United States and associated threats to these wetlands can be found in Kirkman et al. 1999 (entire), Brinson and Malvárez 2002 (pp. 115-120, 126-129), and Tiner 2003 (entire). Unlike wetlands associated with navigable waterways, isolated wetlands have experienced less regulatory protection over time (Kirkman et al. 2000, pp. 553-554; Haukos and Smith 2003, pp. 582-586; Rains et al. 2016, entire).

The eastern black rail also uses the transition zone (ecotone) between emergent wetlands and upland grasslands. These transitional areas are critical to eastern black rails as they provide refugia during high water events caused by precipitation or tidal flooding. These habitat types have also experienced significant declines over time (Sampson and Knopf 1994, pp. 418-421), with many areas in the eastern black rail's historical range losing over 90% of their prairie habitat. Most of this loss can be attributed to agricultural conversion (Sampson and Knopf 1994, pp. 419-420). Many of the freshwater wetlands associated with these grasslands were emergent and ephemeral in nature and would have supported eastern black rails. For example in Texas, between the 1950s and 1990s, 235,000 ac or 29% of freshwater wetlands within Gulf coastal prairie were converted primarily to agriculture. This value does not account for the numbers of upland prairie acres that were also converted (Moulton et al. 1997, entire).

It should be noted that most status and trend reports examine the presence and absence of wetland habitat and their wetland type. These reports typically do not address habitat quality or level of associated disturbance which would influence habitat suitability for the eastern black rail. Given the species narrow requirements of utilizing the wetland-upland interface, shallow water, and dense cover, it is difficult to estimate the proportion of wetland loss associated with the above reports that would account for eastern black rail habitat. However, as a wetland dependent subspecies, the loss and alteration of palustrine and estuarine wetlands and associated grassland habitats would have a negative impact on the eastern black rail.

### 3.2 Altered Plant Communities

Grasslands and associated emergent wetland habitats require periodic disturbance to re-initiate succession. This is particularly true for palustrine environments and less so with estuarine environments where salinity plays a role in the exclusion of most woody vegetation species, with a few exceptions. Prior to European settlement in North America, fire in grasslands and emergent wetlands would typically be the cause of disturbance which re-initiates the successional stage

(Anderson 2006, p. 641). In modern times, fire suppression has allowed many types of grasslands to be encroached by woody species leading to the loss of grassland dependent wildlife (Hunter et al. 2001, p. 445).

Changing temperatures have also influenced estuarine systems by allowing salt marsh habitat encroachment by mangrove species. Eastern black rails may be able to tolerate the early invasion of salt marshes by mangroves, but will presumably abandon a site when mangroves become more established. In northeast Florida, mangrove encroachment into salt marshes is evidenced with red (*Rhizophora mangle*) and black (*Avicennia germinans*) mangroves expanding their range northward due to a general increase in temperature (Cavanaugh et al. 2014, p. 724). The historical (1942-1980) northern limit of mangroves on the United States Atlantic Coast, seemingly dictated by cold temperatures, was approximately 30°N and just north of St. Augustine, Florida (Cavanaugh et al. 2014, p. 723; Rodriguez et al. 2016, p. 246). Whereas the southern limit of temperate salt marshes was approximately 28°N, with mangroves and salt marshes coexisting between the two latitudes, 28°N to 30°N (Cavanaugh et al. 2014, p. 723). However, from 1984 to 2011, mangroves doubled in their spatial extent between 29° and 29.75°N (Cavanaugh et al. 2014, p. 724). General increases in temperature and decreases in the frequency of extreme cold events are expected to continue with global climate change (Cavanaugh et al. 2014, p. 723). As a result, some mangrove species, including black mangroves within the eastern black rail range, are projected to expand toward the North and South Poles by at least 2 degrees of latitude by 2080 (under varying sea level rise projections) (Record et al. 2013, pp. 11-12). As evidenced by the extirpation of another tidal marsh bird, the MacGillivray's seaside sparrow, between 29.0°N to 30.4°N on the Atlantic Coast, mangrove expansion has the potential to cause species' extirpation from an area (Kale 1983, pp. 42-45). However, mangrove expansion will not be uniform across a mangrove species' range. A study of the entire Texas Gulf Coast suggested that mangroves and salt marsh grasses may alternate occupancy of Texas marshes in accordance with fluctuations in accretion, temperature, and carbon dioxide response as opposed to shifting entirely to mangrove dominance (Armitage et al. 2015, p. 14).

Plant communities have also been affected by relative sea level rise where emergent marsh habitats have been converted to open water. In addition, human modifications to the environment have led to significant changes in the vegetation community. Some of these modifications include construction of levees, drainage canals, and dams, and water withdrawals. Changes in the native vegetation community can result in changes to the structure of the habitat (e.g., conversion from emergent to scrub-shrub wetlands, wetland into upland habitat, or vice-versa), as well as the introduction of invasive plant species (e.g., *Phragmites australis;* Crain et al. 2009, p. 157). Invasive species (both native and exotic) have played a role by converting emergent systems into shrub or tree dominated landscapes or monocultures (Grace et al. 2005, p. 23). Given the narrow habitat preferences of the eastern black rail, i.e., very shallow water and dense emergent vegetation, small changes in the plant community can easily result in habitat that is not suitable for the subspecies.

## 3.3 Altered Hydrology

Humans have altered natural hydrologic regimes in order to achieve specific goals for society. These include improvements to drainage systems to reduce flooding of infrastructure and agricultural investments, channels to improve navigation, levees for flood protection, dams to provide water supply and reduce downstream flooding, and withdrawal of surface water and groundwater for agricultural and municipal water supply. These changes have had intentional and unintentional impacts to wetlands associated with the affected water bodies and subsequently impact wetland dependent species, including the eastern black rail.

### *3.3.1 Groundwater Declines*

Within the range of the eastern black rail, land use in the United States has and continues to impact groundwater and surface water resources (Johnston 1997, entire; McGuire 2014, pp. 1-2, 7, 9; Barfield 2016, pp. 2-4; Juracek and Eng 2017, pp. 1, 11-16). The conversion of wetland habitat largely for agricultural use in the United States was mentioned previously, under Section 3.1. However, there are direct and indirect effects of habitat conversion and land use in relation to water resources largely related to the interaction of groundwater and surface water resources (Sophocleous 2002, entire; Tiner 2003, p. 495; Glazer and Likens 2012, entire; Konikow 2015, entire; USGS 2016a, unpaginated).

Where groundwater resources are hydrologically connected to surface water resources, these connections can either be unconfined (water table) or confined (springs) aquifers. In unconfined aquifers, there are locations that can support surface features such as wetlands or riparian habitats where groundwater is located near the land surface (Haag and Lee 2010, pp. 16-19; 21-24). Lowering of groundwater through withdrawals via wells or ditches can cause wetlands to shrink and/or become dry. Withdrawals of confined aquifers can lead to the drying of springs and associated wetland habitats (Weber and Perry 2006, p. 1255; Metz 2011, p. 2).

In the central and south-central United States, high groundwater use largely attributed to cropland irrigation and other anthropogenic activities has led to concerns about the long-term sustainability and changes in water resources resulting in wetland loss (McGuire 2014, entire; Juracek 2015, entire; Juracek and Eng 2017, entire; Juracek et al. 2017, entire; Perkin et al. 2017, entire). More specifically, current water use in the region is a primary cause of aquifer storage depletions, water table declines, and related impacts on surface water, from activities such as stream dewatering (Sophocleous 2002, entire). Ongoing water issues are evidenced in south-central Kansas where a groundwater impairment complaint was filed April 8, 2013 by the

Service on behalf of Quivira NWR to the Kansas Department of Agriculture – Division of Water Resources following over 30 years of significant water shortages (Barfield 2016, p. 2). The final impairment investigation report found that the Service was impaired from exercising its senior water right for the NWR "regularly and significantly" by upstream, junior groundwater pumping (Barfield 2016, p. 4); a solution to the impairment is currently being developed. Quivira NWR manages a large wetland complex (approximately 7,000 ac) in the Central Flyway and currently supports one of two known consistent breeding populations of eastern black rail in the interior United States (the other breeding population being in the Arkansas River Valley in Colorado).

Groundwater aquifers in Florida have significant surface connections in both confined and unconfined aquifers (USGS 2016b, unpaginated). Groundwater withdrawals have affected wetlands in Florida since many of the wetlands have connections to groundwater resources (Haag and Lee 2010, p. 37; Metz 2011, p. 42). Water use in general is expected to increase in Florida by 16% by 2030 (Florida Department of Environmental Protection 2015, p. 2). While water management plans set minimum flow levels for specific natural resource areas, sites, or water bodies, all of these targets are not currently being met and not all habitats that might be used by eastern black rails are covered by a minimum flow level. There are uncertainties associated with how water resource management can balance the water needs for people and natural resources into the future given the expected levels of human population growth.

The increasing demands on groundwater in the United States in combination with the effects of long-term climate trends (e.g., increased frequency of drought) signify changes in the quantity and quality of aquatic systems (e.g., streams, groundwater-dependent systems) and associated wildlife (Juracek et al. 2017, entire; Perkin et al. 2017, entire). Aside from the more obvious impacts on soil moisture and surface water, potential effects of water table declines and reductions in streamflow on eastern black rail wetland habitat and food resource conditions include shifts in riparian/wetland vegetation communities (Henszey et al. 2004, entire) and invertebrate biomass (Davis et al. 2006, entire).

### *3.3.2 Subsidence*

Groundwater-related subsidence (lowering or sinking of the earth's surface) is caused by the withdrawal of liquids from below the ground's surface (White and Tremblay 1995, entire; Day et al. 2011, p. 645; Karegar et al. 2016, p. 3129). Localized subsidence can occur with groundwater withdrawals in locations where withdrawal rates are greater than the aquifer recharge rates (White and Tremblay 1995, pp. 794-804; Morton et al. 2006, p. 271) or where liquids associated with hydrocarbon extraction have caused the lowering of ground elevations (Morton et al. 2006, p. 263). On the Atlantic coast, an area of rapid subsidence exists between Virginia and South Carolina and the rate of subsidence has doubled due to increased groundwater withdrawals (Karegar et al. 2016, pp. 3131-3132). This area of the Atlantic coast had significant numbers of eastern black rails historically and continues to support the subspecies although in fewer numbers (Watts 2016, pp. 68-92). An extreme example of subsidence in the United States is along the Gulf of Mexico coast where both subsurface liquid withdrawal and sediment consolidation have significant influence on coastal wetland habitats (Turner 1990, pp. 93-94, 96, 98; White and Tremblay 1995, pp. 795-804; Morton et al. 2006, entire). Subsidence combined with sea level rise is referred to as relative sea level rise, and the Gulf of Mexico has the highest relative sea level rise rates in the conterminous United States leading to significant losses in wetland habitats (NOAA 2018, unpaginated).

Subsidence can affect eastern black rail and its habitat in both fresh and tidal wetlands. Vegetated wetland habitats used by the eastern black rail can be converted to un-vegetated open water or mudflats through drowning of vegetation or erosion from increased wave energy. Locations with higher subsidence rates can experience increased tidal flooding sooner than areas with lower subsidence rates. The effect of increased tidal flooding will change eastern black rail habitat over time, such as through marsh migration, and can have direct impacts on black rail reproduction when flooding occurs during the breeding season. See potential impacts from tidal flooding in Section 3.5.1.

### *3.3.3. Drainage Modifications*

Extensive drainage features have been created or modified in the United States primarily to reduce flooding to protect agricultural land or infrastructure. These include excavation of drainage ditches, channelization of rivers and streams, construction of levees and berms, construction of tidal restrictions, and the diversion of waterways. The loss or conversion of wetlands has been a direct goal in some cases and unintentional in others. Extensive areas of Florida were channelized in an effort to drain wetlands in the early 1900s (Renken et al. 2005, pp. 37-56). Most of the Texas Coastal Plain has experienced newly created or improved existing drainage features to reduce flooding of agricultural lands and associated communities. These improved drainage features can reduce or eliminate the natural hydroperiod to sustain associated wetlands by removing water rapidly off the landscape (Blann et al. 2009, pp. 919-924). In glaciated geographies such as the Midwest, drain tiles and other methods were used to drain wetlands to improve conditions for agricultural production (Blann et al. 2009, pp. 911-915). Prior to World War II, approximately 90% of the salt marshes on the northeast United States coast were ditched to control mosquitoes (Bourn and Cottam 1950, p. 15; Crain et al. 2009, pp. 159-161). Ditching increased the area of the marsh that was inundated as well as drained (Daiber 1986 in Crain et al. 2009, p. 160; Crain et al. 2009, p. 160).

An alternative approach to ditching, Open Marsh Water Management (OMWM), to address mosquito populations in marshes while ameliorating the negative impacts of ditching has been developed in the last few decades (Mitchell et al. 2006, p. 167). This approach creates ponded areas of the marsh and also plugs previously constructed ditches in order to maintain access to potential mosquito larvae by fish. This approach is not entirely accepted by wetland experts and land managers due to altering, fragmenting, and converting of pristine marshes to create ponded areas, compacting emergent marsh from heavy equipment activities on the surface, changing vegetation community and allowing invasion of shrubs and non-native species due to elevation changes, and losing salt marsh habitats used by wetland species (Mitchell et al. 2006, pp. 167, 169). However, potential beneficial effects of OMWM in altered marshes is increased forage base and feeding habitats for waterbirds, restoration of hydrology by plugging ditches, and addition of perching and nesting substrates for wetland birds (Mitchell et al. 2006, p. 169). While OMWM has potential benefits to some wildlife species, the effects on the eastern black rail have not been evaluated.

Levees have been incorporated in flood prone areas to minimize damage to crops and local communities. Levees can modify the duration, intensity, and frequency of hydroperiods associated with riparian and tidal wetlands and thus change the nature and quality of wetland habitat used by marsh dependent species (Walker et al. 1987, pp. 197-198; Bryant and Chabreck 1998, p. 421; Kuhn et al. 1999, p. 624; Kennish 2001, p. 734; Adam 2002, p. 46). Levees also facilitate the movement patterns of mesopredators (middle trophic level predators) and improve their access to wetland habitats (Frey and Conover 2006, pp. 1115-1118). Navigation channels and their management have had extensive impacts to tidal wetlands (e.g., in Louisiana) by modifying the vegetation community of associated wetlands and increasing the frequency of extreme high tide or high flow events on tidal wetlands by providing a more direct connection to the influencing water body (Turner 1990, pp. 97-98; Bass and Turner 1997, pp. 901-902; Kennish 2001, pp. 734-737). Tidal restrictions such as water control structures, bridges, and culverts, have also affected coastal salt marshes. Their purpose includes providing flood protection, restricting salt water intrusion, and modifying vegetation. However, these tidal restrictions can limit marsh accretion, nutrient exchange, and habitat use by certain saltmarsh dependent bird species (Brawley et al. 1998, pp. 629-632; Gedan et al. 2009, p. 127).

These alterations to drainage affect the hydrology, sediment and nutrient transport, and salinity which in turn affect the composition and structure of wetland habitats used by the eastern black rail. These changes can lead to wetland ecosystem instability with regard to duration and intensity of hydroperiods resulting in wide swings in salinity and water levels. This affects associated vegetation communities, and impacts the ability for marsh habitats to adapt to changing conditions. By exposing eastern black rails to unsuitable water regimes or converted habitats, these factors all affect the ability of the habitat to support viable populations of eastern black rail.

## 3.4 Land Management

Land management activities can have profound effects on habitat for fish and wildlife resources including the eastern black rail. This is especially true for grassland habitats and their emergent wetland habitat components whose associated plants, animals, and microorganisms have evolved with fire and grazing. Many grassland and emergent wetland habitats require disturbance to re-initiate succession (Hunter et al. 2001, p. 445).

### *3.4.1 Fire*

Historically, fire has been used for goals other than wildlife habitat management, such as visibility improvement, convenience, agricultural resource access, livestock management, and pest control. Manmade fires that helped maintain grasslands were once prevalent in many coastal and interior grassland areas of the United States. Increased agricultural activities and fire suppression practices have led to a greater prevalence of shrubs and trees across the landscape and a decrease in fire frequency that would maintain grasslands (Grace et al. 2005, pp. 22-23; Anderson 2006, pp. 634-635, 641; Noss 2013, pp. 63-68).

Fire suppression has been detrimental in allowing woody plant encroachment into habitats used by the eastern black rail. In palustrine habitats, these plants can be native trees and bushes as well as invasive exotics such as Chinese tallow, giant cane, and common reed. In estuarine habitats, these invasive exotic plants can be Jesuit's bark or mangrove species, although with less detriment than woody vegetation encroachment in palustrine habitats. Without fire or alternate methods for disturbing woody vegetation such as mowing, the amount of suitable habitat for eastern black rails is expected to decrease in some regions, such as coastal Texas (Grace et al. 2005, p. 39). Therefore, prescribed (controlled) fire can maintain habitat for this subspecies at the desired stage (seral or intermediate stage) of ecological succession.

Modern wildlife habitat management efforts to influence coastal salt marshes using fire began approximately ninety years ago, and emphasized the production of furbearers and waterfowl habitat. These efforts included the elimination of plants considered low value at that time, such as *Typha* and *Spartina* species, two cover plants used by the eastern black rail (Mitchell et al. 2006, p. 156). Today, fire management efforts such as controlled burns on conservation lands still often focus on providing waterfowl habitat but also consider woody vegetation control. Controlled burns may also be used to provide nutrient-rich forage for cattle on public and private lands throughout the range of the eastern black rail. While fire is needed for habitat maintenance for multiple species, the timing and frequency of controlled burns as well as the specific vegetation types targeted can lead to undesirable effects on eastern black rail habitats under certain conditions (Eddleman et al. 1988, pp. 464-465).

3.4.1.1 Frequency and Timing

Burning salt marshes during drought or while the marshes are not flooded can result in root damage to valuable cover plants (Nyman and Chabreck 1995, p. 138). Controlled burning of peat, or accumulated organic litter, when marshes are dry has resulted in marsh conversion to open water due to the loss of peat soils. Such habitat losses in the Gulf Coast Chenier Plain are noted as requiring decades to recover if they are even able to do so (Nyman and Chabreck 1995, p.135). Similarly, some marsh plants such as *Distichlis* spp. are sensitive to flooding events immediately following fire and may even disappear following fire under these circumstances (de Szalay and Resh 1997, p. 155). Variations in soil type supporting marsh plants of the same species may lead to differing recovery times post-burn, and therefore potentially unanticipated delays in the recovery of eastern black rail habitat (McAtee et al. 1979, p. 375). Simply shifting the season (timing) of controlled burns may alter plant species dominance and the associated structure available to eastern black rail, as has been documented with spring fire conversion of chairmaker's bulrush to salt meadow cordgrass (Nyman and Chabreck 1995, p. 135).

Prescribed fire that takes place during critical time periods for the subspecies, i.e., mating, egg-laying and incubation, parental care, and flightless molt (Table 2-1), will lead to mortality of eggs, chicks, juveniles, and molting birds. Fall and winter burns are more likely to avoid reproductive season impacts to wildlife (Nyman and Chabreck 1995, p. 138). At Quivira NWR in Kansas, burning timed to avoid sensitive stages of the life cycle (nesting and molt period) has been less detrimental to eastern black rails (Kane 2011, p. 33). In this same location, fall or winter burning allowed for vegetation production by the following nesting season, at least for the fast-growing, tall spikerushes that typify eastern black rail habitat in Kansas (Kane 2011, pp. 33-34). Winter and early spring burns of primarily cattail marshes in California and Arizona improved habitat conditions for Yuma clapper rails while having no apparent effect on black rail occupancy (Conway et al. 2010, p. 2029).

In a study of Texas coastal salt marshes, controlled burning took place at all locations determined to be occupied by eastern black rail (Tolliver 2017, p. 11). Fall and winter (non-growing season) burns that include the bird's primary cover plants (gulf cordgrass and salt meadow cordgrass) on mineral-rich soils are typical at San Bernard, Big Boggy, and Brazoria NWRs. These burns are performed on a 3 to 6 year rotation, with some units burned less frequently (Wilson 2017, pers. comm.). Burning at a 3 to 5 year rotation in salt meadow cordgrass marshes on organic soils at McFaddin NWR does not appear to negatively affect the long-term survival of this plant community and may lead to increases in marsh surface elevation (McKee and Grace 2012, p. 3). It should be noted that these results are not applicable to marshes with differing geologies and other location-specific factors (McKee and Grace 2012, p. 3), such as the adjacent, sandier and firmer marshes west of Galveston Bay that continue to the Laguna Madre (Mendelssohn et al. 2017, pp. 459-461). At St. Marks NWR in Florida, burning of the eastern black rail's marsh habitat occurs only on an infrequent and/or rare interval when fire escapes adjacent controlled burns in upland pine habitats; in these instances, the marsh habitats are permitted to burn (USFWS 2013, p. 63). In cattail and spikerush dominated wetlands at Quivira NWR in Kansas, light frequency fires (defined as every other year or less often) or moderate frequency fires (defined as fire every other year while accompanied by annual grazing) may have a lower impact on eastern black rail habitat than more frequent fires (Kane 2011, p. 33). Alternatively, three types of disturbance (i.e., burning, haying, and mowing) were conducted at Quivira NWR within the same year and constituted heavy habitat disturbance, which was shown to not promote eastern black rail occupancy (Kane 2011, p. 33).

3.4.1.2 Pattern and Extent

Fire pattern can have profound negative effects on birds. Controlled burns can result in indirect rail mortality as avian predators attracted to smoke are able to capture rails escaping these fires (Grace et al. 2005, p. 6). Because eastern black rails typically choose concealment rather than flight to escape threats, the birds may attempt to escape to areas not affected by fire such as wetter areas or adjacent areas not under immediate threat (Figure 3-1). Therefore, ring, expansive, or rapidly moving fires are not conducive to rail survival (Legare et al. 1998, p. 114; Grace et al. 2005, p. 9), as this could result in direct morality of black rails concealed in cover and/or not able to escape the fire.

Figure 3-1. An adult eastern black rail (*Laterallus jamaicensis jamaicensis*) attempting to conceal itself at the base of a palm tree following a fire in Florida. Photo by J. Baker, U.S. Fish and Wildlife Service.

Controlled burns designed to include unburned patches of cover may positively influence eastern black rail survival. For example, burning 90% of a 2,400-acre marsh in Florida resulted in direct mortality of at least 39 eastern black rails, whereas a mosaic of unburned vegetation patches 0.1-2.0 ac in size facilitated eastern black rail survival during a 1,600-acre controlled burn (Legare et al. 1998, p. 114). Prescribed fires that include patches of unburned habitat scattered throughout provide escape cover for the eastern black rail and other wildlife (Legare et al. 1998, p. 114).

Unburned strips of vegetation bordering the inside perimeters of burn units also are believed to be helpful by providing escape cover from both fire and avian predators (Grace et al. 2005, p. 35). In addition, coastal marshes that are burned in staggered rotations to create a mosaic of different intermediate successional stages or are burned less frequently will continue to provide cover for marsh species, including the eastern black rail (Block et al. 2016, p. 16).

### *3.4.2 Haying and Mowing*

Haying and mowing are utilized throughout the range of the eastern black rail. Haying and mowing are used as habitat management techniques to maintain grasslands by reducing woody vegetation encroachment and also for the production of forage for livestock. These practices can have detrimental impacts to the eastern black rail when used too frequently or during a sensitive time of year for the subspecies. For example, at Quivira NWR in Kansas, haying at a frequency of once or twice per year resulted in no occupancy of hayed habitats by eastern black rails during the following year (Kane 2011, pp. 31-33). Further, it was concluded that haying or mowing timed to avoid sensitive stages of the life cycle (nesting and molt period) would be less detrimental to eastern black rails (Kane 2011, p. 33). Mowing during the spring or summer will disrupt reproductive efforts of migratory birds, and eastern black rails reproduce from approximately mid-March through August (Table 2-1). Mowing during this time period will disturb eastern black rail adults by flushing them off nests and can potentially crush eggs and chicks. As with fire, when mowing is alternated across a respective site to allow areas of unmown habitat at all times, the site can continue to support cover-dependent wildlife such as the eastern black rail.

### *3.4.3 Grazing*

Cattle grazing occurs on public and private lands throughout the range of the eastern black rail. Because eastern black rails occupy drier areas in wetlands and require dense cover, they are believed to be more susceptible to grazing impacts than other rallids (Eddleman et al. 1988, p. 463). Based on current knowledge of grazing and eastern black rail occupancy, the specific timing, duration, and intensity of grazing will result in varying impacts to the eastern black rail and its habitat. Light-to-moderate grazing may be compatible with eastern black rail occupancy under certain conditions, while intensive or heavy grazing is likely to have negative effects on eastern black rails and the quality of their habitat.

Light-to-moderate grazing may benefit black rail habitat (or at least not be detrimental), when herbaceous plant production is stimulated (Allen-Diaz et al. 2004, p. 147) and the necessary overhead cover is maintained. In Kansas, eastern black rails were documented in habitats receiving rotational grazing during the nesting season that preserved vegetation canopy cover (Kane 2011, pp. 33-34). Occupied areas with the most eastern black rail detections experienced different levels of grazing (and burning): areas one year post-burn with and without grazing, areas two years post-burn with grazing, and areas burned earlier in the year without grazing (Kane 2011, p. 33). However, it was surmised that winter grazing would negatively impact habitat quality for the following nesting season by removal of cover a short time in advance of the nesting season (Kane 2011, p. 34). In Texas, eastern black rail occupancy and abundance estimates were highest relative to dense cover in a study that examined the relationship of occupancy to cover, while superimposed on grazed and non-grazed lands (grazing intensity was unquantified) (Tolliver 2017, p. 27). As eastern black rails were present on both grazed and non-grazed refuges, grazing was determined to not be a required management technique to maintain the subspecies in coastal salt marshes in Texas. In Florida, eastern black rail habitat occurs in tidal marshes not utilized for grazing (Schwarzer 2018, pers. comm.). It is possible that a separation of eastern black rail habitat and currently grazed lands occurs in other portions of the subspecies' range as well. In addition, in inland California, California black rail occupancy in wetlands that experienced light-to-moderate winter-spring grazing was more impacted in non-irrigated settings than in irrigated locations (Richmond et al. 2012, p. 1662). The reason for differing occupancy responses between irrigated and non-irrigated wetlands was unknown and more research is needed (Richmond et al. 2012, p. 1662).

As outlined above, studies have documented the occurrence of black rails in habitats receiving light-to-moderate grazing (i.e., Kane 2011, pp. 33-34; Richmond et al. 2012, 1662; Tolliver 2017, p. 27). These results suggest that such grazing is an option for providing disturbance, which may promote eastern black rail occupancy. However, cattle grazing at high intensities may not favor black rail occupancy as heavy grazing, or overgrazing, reduces the wetland vegetation canopy cover (Richmond et al. 2010, p. 92). For example, a significant cover plant for the eastern black rail, gulf cordgrass, is also a forage plant for beef cattle. Mature plants lack nutrient quality and palatability, and gulf cordgrass is maintained in an immature condition with burning at arbitrary frequencies to satisfy grazing objectives (McAtee et al. 1979, p. 372). Gulf cordgrass can tolerate grazing that suppresses it to an immature state for up to 1.5 years with a stubble height of 10-20 cm (Garza, Jr, et al. 1994, p. 16). However, maintaining gulf cordgrass at low stubble heights can result in elimination of the overhead canopy that is needed by eastern black rails for protection from predators. In gulf cordgrass-dominated habitats along the Texas Gulf Coast, eastern black rail occupancy increased steadily with the number of plant stems in the 10-20 cm height category (Butler et al. 2015, p. 28). Thus, some level of light-to-moderate grazing may be compatible with eastern black rail occupancy when the overhead canopy that the birds require is maintained.

In addition to the loss of vegetation cover and height (Whyte and Cain 1981, p. 66; Kirby et al. 1986, p. 496; Yeargan 2001, p. 87; Martin 2003, p. 22), intensive grazing may also have direct negative effects on eastern black rails by livestock disturbing nesting birds or even trampling birds and nests (Eddleman et al. 1988, p. 463). Heavy disturbance from grazing can also lead to a decline in eastern black rail habitat quality. Excessive livestock grazing can cause increased soil erosion (Walker and Heitschmidt 1986, pp. 428, 430; Warren et al. 1986a, p. 486; Weltz and Wood 1986, p. 263), decreased sediment accumulation and increased soil compaction (Andresen et al. 1990, p. 146; Esselink et al. 2002, p. 27), diminished water infiltration (Warren et al. 1986b, p. 500), and even increased salinities eventually leading to habitat conversion (Esselink et al. 2002, p. 28).

### *3.4.4 Impounded Wetland Management*

Throughout the range of the eastern black rail, large areas of high marsh on public and some private lands are impounded (altered by physical means to permit water level control) and managed primarily for waterfowl. Water levels in these impounded areas are typically too deep for eastern black rail use. Eastern black rails require much drier wetland areas than nearly all other North American rallids. Thus, waterfowl management procedures that are compatible with the maintenance of habitats for several rallid species still may not support black rails (Eddleman et al. 1988, pp. 462-463).

In Texas, a comparison of salt marsh habitats and freshwater impoundments managed primarily for wintering waterbirds revealed that non-breeding eastern black rail use was exclusive to the salt marsh habitats; this was attributed to a lack of dense cover in the managed wetlands (Fitzsimmons 2010, pp. 21, 37). Within managed freshwater wetlands, management burns that remove emergent cover may result in unsuitable habitat for eastern black rails (Richmond et al. 2010, p. 92). Moist-soil management, when including a shallow perimeter that supports the growth of wetland cover plants (saltgrasses, rushes, or sedges) and careful monitoring of flooding depths over time, can provide important habitat for eastern black rails while still benefitting waterfowl on managed lands (Hunter 1990, p. 45). Entire impounded wetlands managed to produce dense vegetative cover and shallow water depths (< 3 cm) were associated with eastern black rail occupancy in South Carolina (Roach and Barrett 2015, p. 1073). In California, research in wetlands managed specifically for black rails generated recommendations that managed wetlands include dense cover, water levels ranging from moist soil to 100 mm depth, and gradual slopes contained therein to allow black rails to move higher on the elevational gradient in response to unexpected increases in water level (Nadeau and Conway 2015, p. 8). This effort generated positive results with increased numbers of birds using the units after management treatments were implemented. Therefore, impounded or managed wetlands can be beneficial to the eastern black rail if managed to provide dense cover and shallow water levels. However, when impounded wetlands are managed for deeper water levels and emergent cover is removed or not available, these areas result in unsuitable habitat for the eastern black rail.

### 3.5 Effects of Climate Change

Given the wide range of the eastern black rail, the effects of climate change vary across the subspecies' range. The climate change projections used in this SSA report are based on Representative Concentration Pathway (RCP) scenarios (see Section 5.3). The RCPs are the current set of scenarios used for generating projections of climate change. There are four RCPs, selected to be representative of the range of theoretically possible atmospheric conditions (measured as "radiative forcing", a reflection of influence on climate) which could exist at 2100, and pathways over this century time for those conditions, as described in more than 100 scenarios in the scientific literature at the time the RCPs were developed (van Vuuren et al. 2011, p. 13). For information about the RCP scenarios, please see van Vuuren et al. 2011 (entire) or Collins et al. 2013 (pp. 1044-1047).

In this SSA report, we use climate change projections based on RCP 4.5 and RCP 8.5, the "medium-low" and "highest" scenarios, respectively, in the RCP set. We did not use the "lowest" scenario, RCP 2.6, because it is based on numerous assumptions that are increasingly viewed as being theoretically but not realistically feasible due to a variety of social, economic, ethical, and technological considerations (e.g., Buck 2016, entire; McLaren et al. 2016, entire; Smith et al. 2016, entire; Williamson 2016, entire; Gambhir et al. 2017, entire; Raftery et al. 2017, entire; European Academies Science Advisory Council, 2018).

The RCP 4.5 and RCP 8.5 scenarios are very widely used together in the scientific community, and these scenarios were selected as the basis of projections for assessing climate change impacts, vulnerability, and adaptation responses in the development of the Fourth National Climate Assessments (U.S. Global Change Research Program 2015, entire). At 2100, the atmospheric conditions under RCP 4.5 are associated with a projected global average temperature that is 2.4 °C (± 0.5 °C) higher compared to 1850-1900, and the conditions under RCP 8.5 at 2100 are associated with a projected global average temperature that is 4.3 °C (± 07 °C) higher compared to 1850-1900 (Collins et al. 2013, pp. 1055-1056).

Using a range of climate change projections based on outcomes of more than one scenario is a widely recommended practice (Nakicenovic and Swart 2000, pp. 11, 23; Harris et al. 2014, p. 8; Mauger et al. 2015, pp. 1-4; Kotamarthi et al. 2016, p. 16), as it is one way to acknowledge and work with uncertainty that is inherent in modeling and uncertainty about future human actions which influence changes in climate. Although Table 3-3 (and other material in this SSA) presents projected temperature outcomes separately for RCP 4.5 and RCP 8.5, these are best viewed as providing a technically plausible range, and that reality is somewhere within this range, rather than at either end. Further, based on current trends in global emissions (Jackson et al. 2017, p. entire), the long-lasting influence of greenhouse gases already in the atmosphere (Collins et al. 2013, pp. 1102-1105; Mauritsen and Pincus 2017, p. entire), and recent analysis of expected emissions through 2040 (U.S. Energy Information Agency 2017, p. entire), there is a very reasonable basis for concluding that changes from now through at least mid-century will be much closer to projections under RCP 8.5 than RCP 4.5. Further, this means that in order to achieve the atmospheric conditions at 2100 which are the basis for the RCP 4.5 scenario beyond mid-century much more substantial reductions in emissions would be needed than are assumed under the RCP 4.5 pathway.

Across the contiguous United States, the average annual temperature has increased 1.2°–1.8° Fahrenheit (F) since the beginning of the 20th century (Vose et al. 2017, p. 186). Within the range of the eastern black rail, the change in annual average temperatures differs by region: Northeast (+1.43°F), Southeast (+0.46°F), Midwest (+1.26°F), and Great Plains South (+0.76°F) (Vose et al. 2017, p. 187); these regions are those used for the Fourth National Climate Assessment and do not correspond to the analysis units in this SSA report. Future projections indicate that the annual average temperature will increase throughout the 21st century. Average temperatures are projected to increase by 2.5°F to 2.9°F from the period 2021–2050 compared to the period 1976–2005, depending on future emission scenarios (Vose et al. 2017, p. 195). By end-of-century (2071–2100), average temperatures are projected to increase between 5.0°F and 8.7°F, depending on the future emissions projections (Vose et al. 2017, p. 195). Projected changes vary across region (see Table 3-3).

Table 3-3. Projected changes in annual average temperature (°F) for regions that support eastern black rail. Adapted from (Vose et al. 2017, p. 197).

| **Region** | **Mid-Century, RCP 4.5** | **Mid-Century, RCP 8.5** | **Late Century, RCP 4.5** | **Late Century, RCP 8.5** |
|---|---|---|---|---|
| Northeast | 3.98°F | 5.09°F | 5.27°F | 9.11°F |
| Southeast | 3.40°F | 4.30°F | 4.43°F | 7.72°F |
| Midwest | 4.21°F | 5.29°F | 5.57°F | 9.49°F |
| Great Plains South | 3.62°F | 4.61°F | 4.78°F | 8.44°F |

While the frequency and intensity of cold waves are expected to decrease throughout the century, the frequency and intensity of heat waves are projected to increase. For example, by mid-century (2036–2065), projections indicate about 20–30 more days per year with a maximum temperature greater than 90°F under RCP 8.5, with increases of 40–50 days in large parts of the Southeast (Vose et al. 2017, p. 199). The projected number of warm nights per year, i.e., the number of days per year with a minimum temperature above 75°F, is expected to increase in the Southeast by mid-century and late century under both RCP 4.5 and RCP 8.5 (Reidmiller et al. 2018, p. 724). Warmer winter temperatures may lead to ecological changes such as salt marsh habitat being replaced by mangrove forests (Osland et al. 2013, entire; Reidmiller et al. 2018, p. 738) and the northward expansion of invasive species, such as red fire ants (Morrison et al. 2005, pp. 202-203).

Surface soil moisture is projected to decrease across regions and seasons in the contiguous United States, which is a result of increasing temperatures leading to greater evapotranspiration (Wehner et al. 2017, pp. 238-239). Although extreme precipitation events are projected to increase in Florida, increased temperatures will result in the loss of soil moisture and more intense drought effects (Runkle et al. 2017a, p. 3). In the southern Great Plains, studies project less soil moisture, with drier conditions (Cook et al. 2015, p. 3; Reidmiller et al. 2018, p. 972). The effects of climate change will likely exacerbate the frequency, duration, and intensity of drought (Wehner et al. 2017, p. 237; Reidmiller et al. 2018, p. 972). When co-occurring with heat waves, droughts can affect bird abundance with changes of up to 15%; further, droughts and heat waves result in higher declines in ground nesting birds than other types of nesters, such as canopy nesters (Albright et al. 2010, p. 9). This may be attributed to higher temperatures experienced by ground nesters compared to canopy nesters.

Between 1901–2015, average annual precipitation across the contiguous United States increased approximately 4%; however, regional and seasonal differences exist (Easterling et al. 2017, p. 208). The fall season has the largest increase in average precipitation (10%). Spring and summer have had about 3.5% increases, although the northern half of the United States has become wetter and the southern half of the United States has become drier (Easterling et al. 2017, p. 208). Future projections of average annual precipitation vary seasonally across regions. In the southern Great Plains, average annual precipitation changes are projected to be small; however, the frequency and intensity of extreme precipitation events are projected to increase (Reidmiller et al. 2018, p. 972).

Extreme precipitation events have increased in the southern Great Plains and the Southeast (Easterling et al. 2017, p. 210). In the contiguous United States, projections indicate that extreme precipitation events will increase in frequency and intensity in the future (Easterling et al. 2017, p. 216). Extreme precipitation events are projected to increase 50–100% by late century, under the RCP 4.5 scenario and to increase by two to three times the historical average by late century under the RCP 8.5 scenario (Easterling et al. 2017, p. 218). These extreme precipitation events are projected to increase in frequency and intensity in the Southeast and southern Great Plains and will directly affect the vulnerability of coastal regions (Reidmiller et al. 2018, p. 970). Ground nesting birds such as the eastern black rail are susceptible to large declines in abundance in association with extreme weather events (Albright et al. 2010, p. 7).

Extreme weather effects such as storms associated with frontal boundaries or tropical disturbances can also directly affect eastern black rail survival and reproduction and can result in direct mortality. Tropical storms and hurricanes are projected to increase in intensity and precipitation rates along the North Atlantic and Gulf Coast (Bender et al. 2010, p. 458; Kossin et al. 2017, pp. 259-260). For tropical storms, modeling efforts suggest that the frequency of Category 4 and 5 storms will increase despite an overall decrease in the number of tropical disturbances (Bender et al. 2010, pp. 457-458). Storms of increased intensity, which will have stronger winds, higher storm surge, and increased flooding, cause significant damage to coastal habitats by destroying vegetation and food sources, as well as resulting in direct mortality. For example, following Hurricane Harvey in August 2017, only five endangered Attwater's prairie-chickens (of 29 birds being tracked) were confirmed alive on the Attwater Prairie Chicken NWR, and three of these five have since gone missing (USFWS 2017b, unpaginated). The eastern black rail is identified as occurring on the Attwater Prairie Chicken NWR and, if present at the time of Hurricane Harvey, was likely impacted by the hurricane and associated flooding. In Figure 3-2, Hurricane Harvey flooded San Bernard NWR with storm surge which was followed by runoff flooding from extreme rainfall. This saltmarsh, occupied by eastern black rails, was inundated for several weeks (Woodrow 2017, pers. comm.). Increases in storm frequency, coupled with sea level rise, may result in increased predation exposure of adults and juveniles if individuals are forced to emerge from dense vegetative cover (Evens and Page, 1986, p. 108; Takekawa et al. 2006, p. 184). Observations show predation upon California black rails during high tides when the birds had minimal vegetation cover in the flooded marsh (Evens and Page 1986, p. 108).

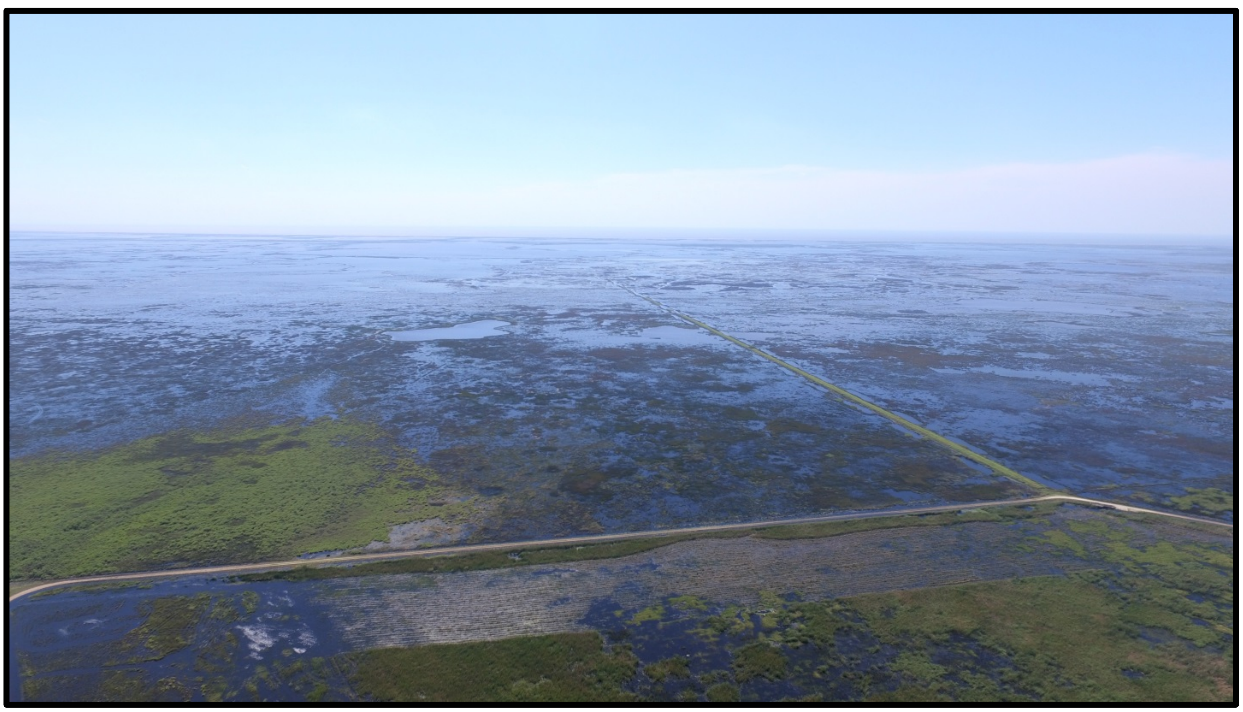

Figure 3-2. Flooded prairie and salt marsh habitat for the eastern black rail at San Bernard National Wildlife Refuge, Texas, following Hurricane Harvey in 2017. Photo credit: C. Jones, U.S. Fish and Wildlife Service.

Weather alterations associated with climate change can have direct effects on the eastern black rail leading to reduced survival of eggs, chicks, or adults, and indirect effects are likely to occur through a variety of means including long-term degradation of both inland and coastal wetland habitats. Other indirect effects may include more secondary causes such as loss of forage base of wetland dependent organisms. Warmer and drier conditions will most likely reduce overall habitat quality for the eastern black rail. Because eastern black rails require a narrow range of water levels and appear to tolerate minor variation within those water levels, drying of habitat as a result of extended droughts may result in habitat becoming unsuitable, either on a permanent or temporary basis (Watts 2016, p. 120). Extreme drought or flooding conditions may also decrease bird fitness or reproductive success by reducing the availability of the invertebrate prey base (Hands et al. 1989, p. 5; Davidson 1992a, p. 129). Lower rates of successful reproduction and recruitment can lead to overall declines in population abundance and resiliency to withstand stochastic events such as extreme weather events. The vulnerability of the eastern black rail to the effects of climate change depends on the degree to which it is susceptible to, and able to cope with, adverse environmental changes due to long-term weather trends and more extreme weather events.

The best available information indicates climate change will result in increased temperatures, decreased precipitation, and an increase of severe weather events such as drought and storms within the range of the subspecies and are likely to have significant influences on the future resiliency of eastern black rail populations. These trends are expected to exacerbate the challenges related to past and ongoing habitat loss making it less likely for populations to withstand extreme weather events that are likely to increase in frequency and severity.

### *3.5.1 Sea Level Rise and Tidal Flooding*

Global mean sea level has risen about 20.3 to 22.9 cm (8 to 9 in) since 1880, with about 7.6 cm (3 in) of that rise occurring since 1993 (Sweet et al. 2017b, p. 1). In the United States, the rate of sea level rise has been higher than the global rate along the Northeast Atlantic coast over the last several decades (Sweet et al. 2017b, p. 9). In low lying areas of the Southeast Atlantic coast, tide gauge analysis reveals as much as 0.30 to 0.91 meters (m; 1 to 3 feet [ft]) of local relative sea level rise in the past 100 years (Reidmiller et al. 2018, p. 728).

Recent studies project global mean sea level rise to occur within the range of 0.35-0.95 m (1.14-3.11 ft) for RCP 4.5 and 0.5-1.3 m (1.64-4.27 ft) for RCP 8.5 for 2100 (Sweet et al. 2017b, p. 13). The Northeast Atlantic and western Gulf of Mexico coasts are projected to have amplified relative sea level rise greater than the global average under almost all future sea level rise scenarios through 2100 (Sweet et al. 2017b, p. 43). This can be explained in part by the glacial isostatic adjustment (ongoing movement of land once under and around ice-age glaciers), withdrawal of groundwater and/or fossil fuels, and effects of the Antarctic ice melt (Sweet et al. 2017b, p. 30).

Along the Texas Gulf Coast, relative sea level rise is twice as large as the global average (Reidmiller et al. 2018, p. 969). Over the past 100 years, local sea level rise has been between 12.7 to 43.2 cm (5 to 17 in) resulting in an average loss of 73 ha (180 ac) of coastline per year and future sea level rise is projected to be higher than the global average (Runkle et al. 2017b, p. 4; Reidmiller et al. 2018, p. 972). In South Carolina, sea level has risen by 3.3 cm (1.3 in) per decade, nearly double the global average, and the number of tidal flood days has increased (Runkle et al. 2017c, p. 4). Projected sea level rise for South Carolina is higher than the global average, with some projections indicating sea level rise of 1.2 m (3.9 ft) by 2100 (Runkle et al. 2017c, p. 4). The number of tidal flood days are projected to increase and are large under both high and low emissions scenarios (Runkle et al. 2017c, p. 4). Similarly in Florida, sea level rise has resulted in an increased number of tidal flooding days, which are projected to increase into the future (Runkle et al. 2017a, p. 4).

Sea level rise will amplify coastal flooding associated with both high tide floods and storm surge (Buchanan et al. 2017, p. 6). High tide flooding currently has a negative impact on coastal ecosystems and annual occurrences of high tide flooding have increased five to ten fold since the 1960s (Reidmiller et al. 2018, p. 728). In addition, extreme coastal flood events are projected to increase in frequency and duration and the annual number of days impacted by nuisance flooding is increasing along the Atlantic and Gulf Coasts (Sweet et al. 2017b, p. 23). In addition, storm surges from tropical storms will travel further inland.

Some tidal wetlands may persist at slightly higher elevations (i.e., “in place”) under sea level rise for a few decades, depending on whether plant primary productivity and soil accretion (which involves multiple factors such as plant growth and decomposition rates, build-up of organic matter, and deposition of sediment) can keep pace with the rate of sea level rise, thus avoiding “drowning” (Kirwan et al. 2016, entire). Under all future projections, however, the rate of sea level rise increases over time (Sweet et al. 2017a, pp. 342-345). A global analysis found that in many locations salt marsh elevation change did not keep pace with sea level rise in the last century and even less so in the past two decades, and concluded that the rate of sea level rise in most areas will overwhelm the capacity of salt marshes to persist (Crosby et al. 2016, entire). Based on RCP 4.5 and RCP 8.5 scenarios and assuming continuation of the average rate of current accretion, projected marsh drowning along the Atlantic coast at late century (2081-2100) ranges from about 75–90 % (Figure 2 in Crosby et al. 2016, p. 96). In this study, the accretion balance (reported accretion rate minus local sea level rise) is negative for all analyzed sites in the Louisiana Gulf Coast and for all but one site in the mid-Atlantic area (Figure 3c and 3d in Crosby et al. 2016, p. 97); both of these areas are part of the range of the eastern black rail.

Sea level rise will reduce the availability of suitable habitat for the eastern black rail and overwhelm habitat persistence. Sea level rise and its effects (e.g., increased flooding and inundation, salt water intrusion) may affect the persistence of coastal or wetland plant species that provide habitat for the eastern black rail (Warren and Niering 1993, p. 96; Morris et al. 2002, p. 2876). Increased high tide flooding from sea level rise, as well as the increase in the intensity and frequency of flooding events, will further impact habitat and directly impact eastern black rails, i.e., through nest destruction and egg loss (Sweet et al. 2017b, pp. 35-44).

#### *3.5.2 Wildfire Patterns*

Fire frequency and ecosystems are tied by links to temperature, soil moisture, relative humidity, wind speed, and vegetation (Wehner et al. 2017, pp. 242-243). Fire management and suppression practices over the past century have changed these relationships from the natural relationship (pre-industrial times). As the rate of lightning strikes increases as a function of increasing temperatures attributed to climate change, lightning-induced wildfires in the Southeast are projected to increase by mid-21$^{st}$ century (Romps et al. 2014, p. 853; Stavros et al. 2014 in Wehner et al. 2017, p. 244). Areas prone to lightning-ignited fires, such as the Gulf of Mexico and Atlantic Coasts, may experience increases in wildfires in the future as temperatures warm and precipitation patterns change (Prestemon et al. 2016, p. 727). In Florida and Texas, increased drought intensity coupled with higher temperatures may result in more frequent wildfires (Runkle et al. 2017a, p. 3; Runkle et al. 2017b, p. 2). The potential for very large fires in the Southern Coastal Plain (including Florida) are projected to increase, which is consistent with increasing temperatures, more frequent heat waves, and reduced soil moisture (Barbero et al. 2015, pp. 894-895).

Both climate change and land use management practices affect the occurrences of wildfire. Fire can destroy habitat for the eastern black rail, as well as cause direct mortality of adults, juveniles, chicks, and eggs. An increase in wildfires, especially those occurring during the breeding season and the flightless molt period across the range of the eastern black rail, will likely contribute to declines in the number of birds.

### 3.6 Oil and Chemical Spills and Environmental Contaminants

#### *3.6.1 Oil and Chemical Spills*

In general, the frequency and amount of oil released into the environment of the United States has decreased over time (Etkin 2001, p. 1292). After 1985, pipelines accounted for 37 times more oil spilled than tankers and barges combined (Etkin 2001, p. 1294). Despite overall trends in the number of oil spills decreasing over time, spills of significance to fish, wildlife, and their habitats continue to present a threat (Etkin 2001, p. 1299; Deepwater Horizon Natural Resource

Damage Assessment Trustees 2016, pp. 1-3). While there is little documentation of impacts to black rails from oil spills, there are data demonstrating impacts to secretive marsh bird species and their habitat that often overlap with habitat used by eastern black rails (Bergeon Burns et al. 2014, p. 825; Bonisoli-Alquati et al. 2016, pp. 5-6; Deepwater Horizon Natural Resource Damage Assessment Trustees 2016, pp. 4:325-378, 4:461-515; Hester et al. 2016, pp. 367-368). While spills are infrequent, the significance of a single event could have drastic short-term and long-term impacts to local habitats and populations of fish and wildlife including eastern black rails (Gerber et al. 2004, pp. 2752-2753; Boehm and Page 2007, pp. 434-441). Extreme storms and flood events can result in a higher risk of chemical spills. For example, one of the impacts of Hurricane Harvey, which was intensified due to climate change (Emanuel 2017, entire), included the flooding of a chemical plant in Baytown, Texas (Bajak and Olsen, 2017, unpaginated). The flooding resulted in the release of 34,000 pounds of sodium hydroxide (also known as lye) and other chemicals into the environment (Bajak and Olsen, 2017, unpaginated). More intense hurricanes and more extreme rainfall events, and associated flooding, are projected under climate change (see Section 3.5 Effects of Climate Change); these catastrophic events may result in an increased risk of chemical spills in the future. In general, the risk to eastern black rails from an oil and chemical spill would be considered low due to the low frequency of those events; however, an event under certain conditions (large spill, weather, tide levels, etc.) where the spill could reach eastern black rail habitats could have significant regional impacts to the subspecies.

### *3.6.2 Environmental Contaminants*

Environmental contaminants pose a risk to birds and have well documented direct effects on individual health, reproduction, and the viability of their young (Reish et al. 1978, entire). Indirect effects may include changes to forage abundance and diversity (Suter 1993, pp. 275-308). While impacts to waterbirds from contaminants have long been studied, there are very few studies regarding contaminants and black rails (Eddleman et al. 1994, unpaginated). There are localized hotspots for certain contaminants and these can pose a risk to local populations (Rattner and Ackerson 2008, p. entire). For example, mercury is a concern for waterbirds including the California black rail in San Francisco Bay since mercury is a neurotoxin and can accumulate and concentrate through the food chain (Takekawa et al. 2006, pp. 185-187; Yee et al. 2008, entire). Organochlorine compounds also can accumulate and concentrate through the food chain and have been identified as a potential risk to avian species at specific locations in the northeastern United States (Rattner and Ackerson 2008, p. 349). California black rails in southwestern Arizona had elevated selenium levels in livers and an egg similar to those levels that cause reproductive failure in mallards (*Anas platyrhynchos*), but the toxicity to blacks rails remains unknown (Flores and Eddleman 1991, p. 63). A concern is the wide-spread use of pesticides to control mosquitoes in marshes that are used by eastern black rails and potential impacts that may occur to the prey base (Morris et al. 2005, pp. 11-12; Poulin et al. 2010, p. entire; Lagadic et al. 2014, pp. 108-109). The importance of mosquitoes to the diet of eastern black rails is currently unknown. However, individuals have been observed to feed on mosquito larvae in the field, as well as consume adult mosquitoes when captured temporarily (Woodrow 2017, pers. comm.; (Hand 2018, pers. comm.).

While there are hotspots for environmental contaminants, there is no evidence of specific threats that might affect the subspecies and demonstrate a population level response. Indirect effects to eastern black rails such as impacts to forage base from certain pesticides require further study.

### 3.7 Disease

Disease is a natural ecological process that afflicts most living creatures including wild birds (Thomas et al. 2007, p. entire). There are no documented cases of disease for the eastern black rail subspecies as a whole (Eddleman et al. 1994, unpaginated). Infectious disease, and in particular the West Nile virus, has been shown to affect bird populations (McLean 2006, pp. 55-57). Fundamental disease etiological science (the study of the causes and origination of disease) suggests that populations exposed to new diseases may lack immunity to these diseases (Naugle et al. 2004, pp. 704, 711). The recent introduction of the West Nile virus in 1999 resulted in significant avian mortality in some species and taxonomic groups of birds, especially corvids (crow family) (McLean 2006, entire; McLean and Ubico 2007, p. 22). Substantial evidence has linked recent West Nile virus activity to continuing declines in several species of songbirds (George et al. 2015, entire). The Center for Disease Control and the U.S. Geological Survey provide maps showing disease activity for several arboviruses including West Nile virus (Figure 3-3; USGS 2018, unpaginated). A wide range of bird species have been tested for West Nile virus including one species of Gruiformes, the American coot (Komar et al. 2003, p. 314). Inoculation of the American coot demonstrated minimal effects to this species (Komar et al. 2003, pp. 312-321). However, West Nile virus has been identified in one collected dead coot in California (Foss et al. 2014, p. 581). Increased resistance has been documented within the house finch for the original West Nile virus strain as has increased susceptibility to new strains of the virus (Worma et al. 2013, entire), demonstrating that the adaptive relationship between the virus, host, and vector is always changing. There are no specific data regarding the effects of West Nile virus on eastern black rails; however, the virus is speculated to be a leading driver of recent local extinction events in the Sierra Foothills population of the California black rail (Risk et al. 2011, p. 472). Precipitation and land-use/land-cover influence the presence of the virus in the environment; however, the relationship is not clear with these factors (Ezenwa et al. 2007, entire; Landesmanet al. 2007, entire). Recent research demonstrated a strong relationship between drought and the occurrence of West Nile virus; projected future increases in West Nile virus epidemic intensity are attributed to an increase in drought and infection prevalence (Paull et al. 2017, p. 5). West Nile virus continues to negatively affect some bird species in North America. The relationship between birds and the virus is under a constant state of flux with changing environmental factors, levels of resistance, and genetic strains of the virus.

While the exact relationship between disease, specifically the West Nile virus, and the eastern black rail is not well defined, increased drought conditions can increase the concentrations of vectors and hosts and because it is a relatively new virus, the eastern black rail may not have adapted to the presence of the virus. Thus, West Nile virus may pose a risk to the eastern black rail subspecies.

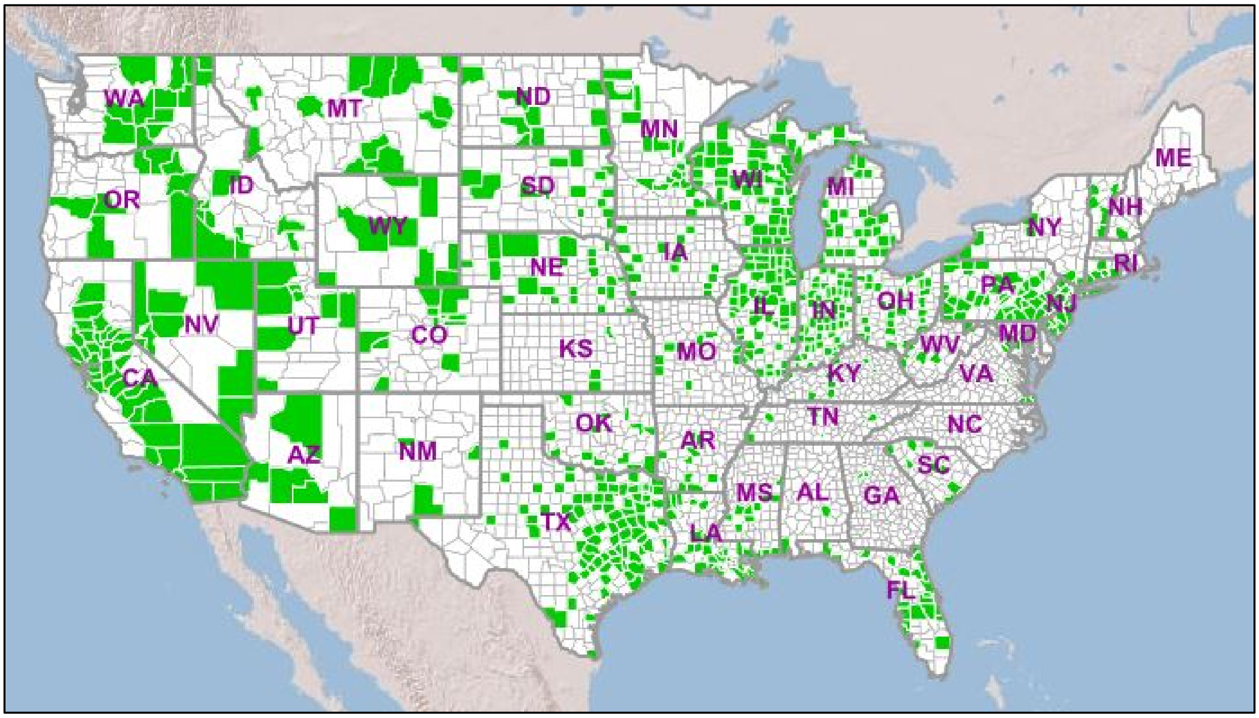


Figure 3-3. Range of West Nile virus non-human infections reported across the contiguous United States in 2016. Counties highlighted in green are reported West Nile virus non-human infections, which demonstrates the presence of the virus within the black rail range. Source: USGS 2018, unpaginated.

### 3.8 Altered Food Webs

Altered food webs have been shown to have negative impacts to species of concern (DeCesare et al. 2010, pp. 353-358). Some of the changes that have occurred include increased predation through human influence, for example availability of food wastes artificially supporting an increased number of predators or the introduction of a new predator species (e.g., raven and fox), or consequences resulting from competition. Conditions can exist where predators, particularly mammalian, are subsidized by human activities resulting in additional pressure on certain prey species (Gompper and Vanak 2008, p. 13; DeCesare et al. 2010, pp. 353-358; Newsome et al. 2015, p. 2). A common example would be locations where human food wastes are not secured and provide additional food sources for predators such as raccoons resulting in increased local abundance by attracting individuals or increasing reproductive success. When subsidized, the higher numbers of predators can place increased pressures on nearby prey species. Subsidized predator populations that would pose a risk to eastern black rails are likely to be associated with locations where people frequent for recreational activities with sufficient habitat to support eastern black rails. Despite documentation for other bird species, there are no specific examples for the eastern black rail.

The imported red fire ant has been documented having impacts to food webs as a predator and as a competitor (Wojcik et al. 2001, pp. 16-21; Pedersen et al. 2003, p. 424; Suarez et al. 2005, entire). The range of the imported red fire ant across the United States is shown in Figure 3-4 (USDA 2017, unpaginated). Recent studies have shown that competition occurs between birds and the invasive fire ant for invertebrate fauna in grasslands (Morrow et al. 2015, pp. 904-905). Grasslands without fire ants present show greater arthropod abundance and brood survival of young birds (Suarez et al. 2005, p. 380). There is one documented case of fire ants depredating a hatching black rail chick (Legare and Eddleman 2001, p. 175).

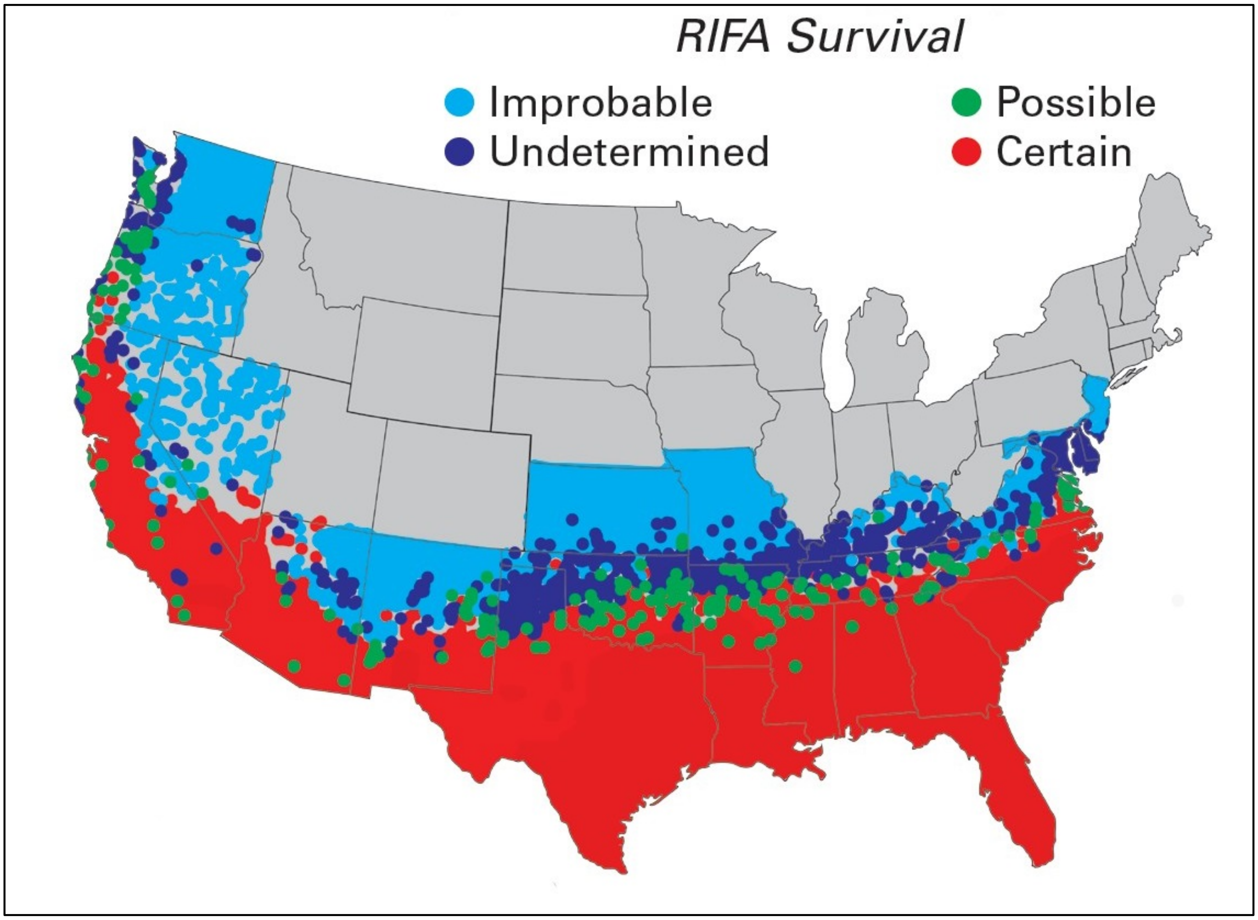


Figure 3-4. Current range and predicted range expansion of the red imported fire ant (RIFA; *Solenopsis invicta*) across the contiguous United States. RIFA survival is certain in the red area and dots, possible in the green dots, undetermined in the dark blue dots, and improbable in the light blue area and dots. Source: USDA 2017, unpaginated.

Feral pigs are known to have significant impacts to native animal and plant communities through direct consumption and indirectly through rooting and soil disturbance (Barrios-Garcia and Ballari 2012, pp. 2284-2293). Feral pigs have been identified as a possible concern as a predator of eastern black rail (Butler et al. 2014, p. 24). The Galapagos rail, a superspecies with the black rail, responded favorably to the removal of feral pigs, goats, and donkeys from one of the islands it inhabits; the number of Galapagos rails increased from 18 individuals in 1986-1987 to 279 individuals in 2004-2005 (Donlan et al. 2007, p. 522). The range and abundance of feral pigs in the contiguous United States is shown in Figure 3-5 (McClure et al. 2015, pp. 11, 17); there is substantial overlap between feral pig occurrence and the range of the eastern black rail.

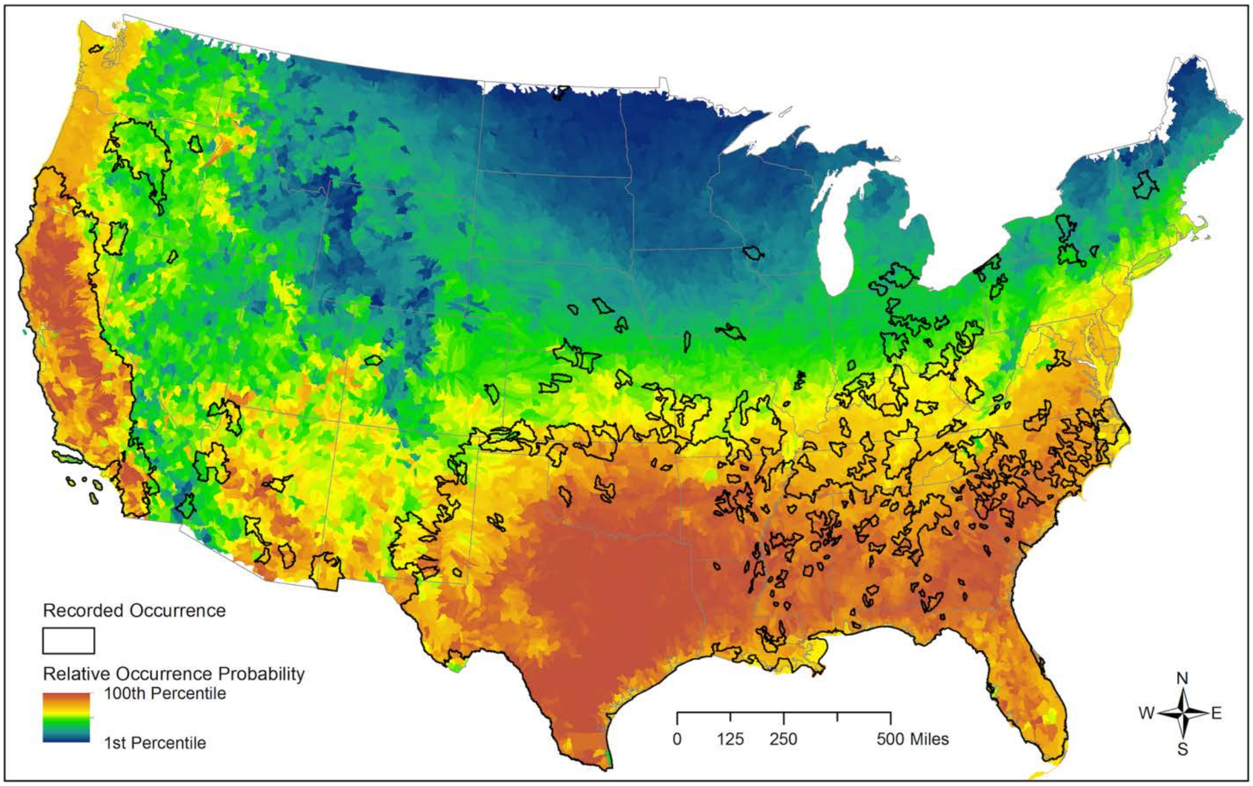


Figure 3-5. Current and predicted range expansion of feral pigs across the contiguous United States. Current range (recorded occurrence) of feral pigs from 1982 to 2012 is outlined in black. Predicted feral pig occurrence is displayed in color based on probability. Source: McClure et al. 2015, p. 11.

Predation by non-native species has likely impacted the eastern black rail in the Caribbean and Florida. The introduction of non-native species, such as the Indian mongoose (*Herpestes auropunctatus*), to island ecosystems has had a significant effect on native birds throughout the world (Hays and Conant 2007, p. 7; Morley and Winder 2013, p. 1). The mongoose has been introduced to Jamaica and Puerto Rico and is responsible for the decline of several ground-nesting birds in these islands (Hays and Conant 2007, pp. 6-7). Mongoose are present in high numbers on the Vieques NWR in Puerto Rico and are known predators of birds. While several species of shore birds have been documented to successfully nest on the NWR (Barandiaran

2016, pers. comm.), there is evidence that the eastern black rail has been extirpated from the island and that mongoose predation contributed to the extirpation (Beissinger 2018, pers. comm.). In addition, non-native green iguanas (*Iguana iguana*) have been introduced to Puerto Rico and are widespread across the territory, including Vieques, and may predate bird eggs and nestlings (López-Torres et al. 2012, pp. 35-36, 43). Burmese pythons, introduced through the pet trade, have expanded their range in Florida considerably (Harvey et al. 2008, entire). Out of 343 Burmese python stomachs examined, birds were found in 89 stomachs and 19 of the 73 birds identified were rallids (Dove et al. 2011, p. 129).

Predation of black rails by various native species has been documented; northern harrier (*Circus cyaneus*), snake species, coyote (*Canis latrans*), raccoon (*Procyon lotor*), great egret (*Ardea alba*), and barn owl (*Tyto alba*) (Eddleman et al. 1994, unpaginated). In particular, predation of California black rails during abnormally high tides has been documented (Evens and Page 1986, p. 108), and is likely an important source of eastern black rail predation in tidally-influenced marshes.

While predation is a natural component to any wildlife population, the introduction of new predators or competitors and the effects that humans have on natural predators can cause higher than expected losses of individuals to a population. Non-native predators also have detrimental impacts on eastern black rail. The presence and prevalence of non-native predators such as feral pigs, exotic reptiles, and fire ants as direct predators and as modifiers of the natural food web would have negative impacts on eastern black rail; however, the size and scope of these effects on the eastern black rail, the subspecies' food base, and its habitat have not been assessed. It is unknown if the eastern black rail will adapt to the presence of new predators such as the Burmese python. Similar situations in other locations such as islands, has led to the extinction of certain bird species, particularly ground-nesting species (BirdLife International 2017, p. unpaginated).

### 3.9 Human Disturbance

Human disturbance has been identified as a stressor to wildlife, resulting in changes in distribution, behavior, demography, and population size (Gill 2007, p. 10). Human activities, such as birdwatching and hiking, have been shown to disturb breeding and nesting birds. Disturbance may result in nest abandonment, increased predation, and decreased reproductive success. Disturbance may also result in behavioral changes in non-breeding birds. Singing activity of male birds has been observed to decline in sites that experience human intrusion, although the response of birds varied among species and level of intrusion (Gutzwiller et al. 1994, p. 35). At the Tishomingo NWR, recreational disturbances of migratory waterbirds accounted for 87% of all disturbances (followed by natural disturbances [10%] and unknown disturbances [3%]) (Schummer and Eddleman 2003, p. 789).

Rare birds are often desired by birders to add to their "Life List" – a list of every bird species identified within a birder's lifetime. Locations of rare birds may be posted online on local birding forums or eBird, leading to an increased number of people visiting the location in an attempt to see or hear the bird. Due to its rarity, the eastern black rail is highly sought after by birders (Beans and Niles 2003, p. 96). Devoted birders may go out of their way to add an eastern black rail their list (McClain 2016, unpaginated). The efforts of birders to locate and positively identify rare birds, such as the eastern black rail, can have both positive and negative impacts on the bird and its habitat. Birders play an especially important role in contributing to citizen science efforts, such as the eBird online database, and have helped further our understanding of species' distributions and avian migration ecology in crucial ways (Sullivan et al. 2014, entire). Birders have provided valuable location information for eastern black rails that might have otherwise gone undetected and have made these records publicly available (see eBird's black rail account; eBird 2017, unpaginated).

While amateur and professional birding have made important contributions to our understanding of rare species distributions, like the eastern black rail, some birders may be more likely to pursue a sighting of a rare bird, as they may perceive the benefits of observing the bird to outweigh the impacts to the bird (Bireline 2005, pp. 55-57). As a result, methods may be employed to increase the likelihood of observing a rare bird, including the use of vocalized calls or audio recordings, as is the case for black rails, or approaching birds in order to get a sighting (Beans and Niles 2003, p. 96; Bireline 2005, p. 55). These methods have the potential to disturb nesting birds, trample nests or eggs, and may lead to increased predation (Beans and Niles 2003, p. 96).

With the availability of smartphones, the use of playback calls has increased as recordings of birds are readily available on the internet, and birding websites and geographic site managers (State, Federal, or Non-governmental Organizations) often provide guidance on the use of playback calls (Sibley 2001, unpaginated). The American Birding Association's Code of Birding Ethics encourages limited "use of recordings and other methods of attracting birds, and [to] never use such methods in heavily birded areas or for attracting any species that is Threatened, Endangered, of Special Concern, or is rare in your local area." (American Birding Association 2018, unpaginated). While most birders likely following these ethical guidelines, using playback calls of black rail vocalizations in attempts to elicit responses from the birds and potentially lure them into view is commonly done outside of formal black rail surveys (see comments for black rail detections on eBird; eBird 2017, unpaginated); note that some black rail detections do report that no playback was used. Due to the rarity of the eastern black rail, a few cases of trespassing are known from people looking for the bird. Trespassing has been documented on private lands and in areas on public lands specifically closed to the public to protect nesting eastern black rails (Hand 2017, pers. comm.; Roth, 2018, pers. comm.). Trespassing may not only disturb the bird, but can also result in trampling of the bird's habitat, as well as eggs and nests. There is concern among State resource managers and researchers that releasing locations of eastern black rail detections may increase human disturbance and harassment to the subspecies.

## 3.10 Conservation Measures

### *3.10.1 Migratory Bird Treaty Act*

The Migratory Bird Treaty Act of 1918 (16 U.S.C. 703 *et seq*.) is the Federal law providing specific protection for the eastern black rail due to its status as a migratory bird. The Migratory Bird Treaty Act (MBTA) prohibits the following actions, unless permitted by Federal regulation: to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird…or any part, nest, or egg of any such bird." Through issuance of Migratory Bird Scientific Collecting permits, the Service ensures that best practices are implemented for the careful capture and handling of eastern black rails during banding operations and other research activities. The December 22, 2017 Solicitor's Opinion, Opinion M-37050, concludes that "consistent with the text, history, and purpose of the MBTA, the statute's prohibitions on pursuing, hunting, taking, capturing, killing, or attempting to do the same apply only to affirmative actions that have as their purpose the taking or killing of migratory birds, their nests, or their eggs." Therefore, take of an eastern black rail, its chicks, or its eggs that is incidental to another lawful activity does not violate the MBTA.

### *3.10.2 Coastal Management*

The Coastal Zone Management Act of 1972 (P.L. 92-583) (86 Stat. 1280; 16 U.S.C. 1451-1464) provides Federal funding to implement the states' federally approved Coastal Zone Management Plans. All coastal states in the eastern black rail's range have approved Coastal Zone Management Plans, which guide and regulate development and other activities within the designated coastal zone of each state (NOAA 2016, unpaginated). The Federal Consistency provision of the Coastal Zone Management Act requires Federal action agencies to ensure that the activities they fund or authorize are consistent, to the maximum extent practicable, with the enforceable policies of that state's federally approved coastal management program (16 U.S.C. 1456).

The Clean Water Act (CWA) and the Rivers and Harbors Act have sections (404 and 10, respectively) that contain provisions for the protection of jurisdictional wetlands from excavation and/or filling activities. The U.S. Army Corps of Engineers in conjunction with the U.S. Environmental Protection Agency administers permits that consider avoidance, minimization and compensation for projects affecting wetlands. Projects that cannot avoid impacts to wetlands must compensate their impacts through a restoration enhancement and/or preservation action for the equivalent functional loss. Mitigation banks are often used which tend to centralize compensation actions at a specific location for impacts in a considerably wider service area. Exact wetland types are not always restored or enhanced and there is considerable uncertainty that current mitigation practices would support the presence of black rails. The status of geographically isolated wetlands under the CWA has fluctuated with different court cases and rulings (Kirkman et al. 2000, pp. 553-554; Haukos and Smith 2003, pp. 582-586; Rains et al. 2016, entire).

#### *3.10.3 Conservation Lands*

Suitable habitat for eastern black rail can be found within NWRs, National Parks and Seashores, state parks, preserves, wildlife management areas, and other conservation lands across the subspecies' range. The National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd *et seq*.) establishes the protection of biodiversity as the primary purpose of the NWR system; recreational and other uses of a NWR may only be approved if the Service finds such uses to be compatible with the purposes of that individual NWR and the purposes of the NWR system.

Habitat for eastern black rails can also be found within National Parks and Seashores, which must balance visitation and recreation with the protection of natural resources like the eastern black rail and its habitat. The National Park Service Organic Act of 1916, as amended (39 Stat. 535, 16 U.S.C. 1), states that the National Park Service (NPS) "shall promote and regulate the use of [NPS units]…to conserve the scenery and the national and historical objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." In addition to the NPS Organic Act, the eastern black rail may benefit from a 2010 non-regulatory Memorandum of Understanding (MOU) between the NPS and the Service regarding migratory birds that was executed pursuant to Executive Order 13186; section F.4 of the MOU states that the NPS will identify and protect natural habitats of migratory bird species within park boundaries.

Numerous conservation properties managed by State and non-governmental organizations also support habitat for eastern black rail. Protected lands such as Wildlife Management Areas, State Parks, State Natural Areas, and Preserves typically have rules that protect wildlife and prohibit the collection, destruction, or disturbance of plants and nongame animals. These lands are often managed for a suite of wildlife species while providing outdoor recreation opportunities to the public.

Recent (2011 to 2017) eBird records of eastern black rails indicated a large number of these records occurred either on or within a kilometer of protected lands. This result may be a bias toward opportunities to detect the subspecies on public lands, may indicate that habitat suitable for the subspecies is more prevalent on protected lands, or a combination of the two. However, based on the available information, protected lands play an important role for the subspecies.

### *3.10.4 State Protections*

Black rail is listed as State Endangered in 7 states within the subspecies' range: Delaware, Illinois, Indiana, Maryland, New Jersey, New York, and Virginia (Table 3-4). The species was formerly listed as endangered in Connecticut, but was considered extirpated during the last listing review based on extant data and subsequently delisted (Connecticut Department of Energy and Environmental Protection 2015a, p. 1; Connecticut Department of Energy and Environmental Protection 2015b, pp. 1-24; Huang 2017, pers. comm.). Protections are afforded to a species but vary by state when it is listed as either State Threatened or Endangered.

In Delaware, the importation, transportation, possession or sale of any endangered species or parts of endangered species is prohibited (except under license or permit) (7 Del.C. § 601 - 605). Illinois statues also include prohibitions on the possession, take, transport, selling and purchasing, or giving of a listed species, and allow incidental taking only upon approval of a conservation plan (520 I.L.C.S. 10/1 – 11). Indiana statutes prohibit any form of possession of listed species, including taking, transporting, purchasing or selling except by permit (I.C. 14-22-34-1 to 12). Listed species may be removed, captured, or destroyed in Indiana only if it is shown by good cause that the species is causing property damage or is a danger to human health (I.C. 14-22-34-1 to 12). Similar prohibitions on the possession of a listed species in any form, except by permit or license, are in effect in Maryland (MD Code, Natural Resources, § 10-2A-01 - 09), New Jersey (NJSA 23:2A-1 to 23:2A-1:15), New York (N.Y. Envtl. Conserv. Law § 11-0535; 6 NY NYCRR 182.1 - .16), and Virginia (Va. Code Ann. §§ 29.1-563 – 570). Violations of the statutes typically result in a misdemeanor, including fines, and forfeiture of the species or parts of the species and the equipment used to take the species. Some States also have provisions for nongame wildlife and habitat preservation programs (e.g., 7 Del.C. § 201 – 204; MD Code, Natural Resources, § 1-705). For example, in Maryland, the State Chesapeake Bay and Endangered Species Fund (MD Code, Natural Resources, § 1-705) provides funds to promote the conservation, propagation, and habitat protection of nongame, threatened, or endangered species.

Black rail is listed as a Species in Need of Conservation in Kansas and requires conservation measures to attempt to keep the species from becoming a State Threatened or Endangered species (Kansas Department of Wildlife, Parks and Tourism 2018, unpaginated). Black rail also is listed as Special Concern in North Carolina and requires monitoring (North Carolina Wildlife Resources Commission 2014, p. 6). The species is identified as a Species of Greatest Conservation Need in many State Wildlife Action Plans (USGS 2017, unpaginated). According to Natural Heritage Programs, black rail is ranked as possibly extirpated in the District of Columbia and in Indiana (NatureServe 2017, unpaginated).

Table 3-4. Black rail (*Laterallus jamaicensis*) state listing and natural heritage rank for states within the range of the eastern subspecies (*L. j. jamaicensis*). States where black rail is considered a vagrant or hypothetical are included. Blank spaces indicate the species is either not state listed or has no natural heritage rank. Natural heritage ranks and rank qualifiers: SH – Possibly Extirpated, S1 – Critically Imperiled, S2 – Imperiled, SNR – Not Ranked, SU – Under Review, B – Breeding, and N – Nonbreeding (NatureServe 2017, unpaginated).

| **State** | **State Listed (Threatened or Endangered)*** | **Natural Heritage Rank†** |
|---|---|---|
| Alabama | | S2N |
| Arkansas | | SU |
| Colorado | | |
| Connecticut | | S1B |
| Delaware | Endangered | S1B |
| District of Columbia | | SHB, SHN |
| Florida | | S2 |
| Georgia | | S1 |
| Illinois | Endangered | S1 |
| Indiana | Endangered | SHB |
| Iowa | | |
| Kansas | | S1B |
| Kentucky | | |
| Louisiana | | S2N, S1B |
| Maine | | |
| Maryland | Endangered | S1 |
| Massachusetts | | |
| Michigan | | |
| Minnesota | | |
| Mississippi | | S2N |
| Missouri | | SU |
| Nebraska | | S1 |
| New Hampshire | | |
| New Jersey | Endangered | S2B, S2N |
| New Mexico | | |
| New York | Endangered | S1B |
| North Carolina | | S2B, S2N |
| North Dakota | | |
| Ohio | | |
| Oklahoma | | S1B |
| Pennsylvania | | |

| State | State Listed (Threatened or Endangered)* | Natural Heritage Rank† |
| --- | --- | --- |
| Puerto Rico | | |
| Rhode Island | | |
| South Carolina | | SNRB, SNRN |
| South Dakota | | |
| Tennessee | | S1 |
| Texas | | S2B |
| Vermont | | |
| Virginia | Endangered | S1B, S1N |
| West Virginia | | |

***Formerly listed as State Endangered in Connecticut – now considered extirpated.
†Missouri defines SU as Unrankable (not as Under Review) (Missouri Natural Heritage Program 2018, p. 6).

## 3.11 Other Conservation Efforts

### *3.11.1 Working Groups*

The Eastern Black Rail Conservation & Management Working Group was initiated by the Center for Conservation Biology in order to coordinate eastern black rail surveys and develop a status assessment (Watts 2016, entire). Comprised of state and federal agencies, universities, and nonprofit staff, the purpose of the working group is to exchange ideas, focus research, and develop approaches to eastern black rail conservation. It is a forum for sharing information about what is known about the subspecies in each state, identifying research and information needs, and communicating approaches to management. Now that the initial status assessment has been completed by the Center for Conservation Biology (Watts 2016, entire), lead coordination of the Atlantic Flyway branch of the Black Rail Working Group has transitioned to the Atlantic Coast Joint Venture (Section 3.11.2). A kick-off call regarding this transition and to refocus the group took place in February 2018.

The Texas Black Rail Working Group was initiated by Texas Parks and Wildlife Department in partnership with the Texas Comptroller's Office in November 2016 (Shackelford 2018, pers. comm.). The main purpose of the group is to provide a forum for collaboration between researchers and stakeholders, share information about what is known about the species, identify information needs, and support conservation actions. The group has held two meetings thus far: January 10, 2017 and November 13, 2017 and produced a newsletter; a third meeting of the Working Group is scheduled for August 2018 (Horndeski and Shackelford 2017, entire).

### *3.11.2 Joint Ventures*

The Atlantic Coast Joint Venture (ACJV) recently decided to focus efforts on coastal marsh habitat and adopted three flagship bird species, one being the eastern black rail, to direct conservation attention in this habitat. As part of this initiative, the ACJV Black Rail Working Group has drafted population goals for the eastern black rail, is developing habitat delivery options, and will be developing a Black Rail Conservation Action Plan for within the Atlantic Flyway. An initial workshop to start development of the Conservation Action Plan is scheduled for October 2018. In addition, the ACJV is coordinating the development of a Saltmarsh Conservation Business Plan. The Business Plan will identify stressors to Atlantic Coast tidal marshes and the efforts needed to conserve these habitats to maintain wildlife populations. The Business Plan is expected to be completed in late 2018.

The Gulf Coast Joint Venture (GCJV) has had the eastern black rail listed as a priority species since 2007 (Gulf Coast Joint Venture 2005, unpaginated). The black rail is provided consideration as are all priority species during the review of North American Wetland Conservation grant applications (Vermillion 2018, pers. comm.). Although detailed planning for eastern black rail is not yet complete, the subspecies is considered in coastal marsh habitat delivery efforts discussed by GCJV Initiative Teams. Eastern black rails are believed to benefit from a plethora of coastal marsh habitat delivery efforts of GCJV partners, including North American Wetland Conservation Act projects, Coastal Wetland Planning Protection and Restoration Act projects, USFWS Coastal Program projects, and management actions on state and federal refuges and wildlife management areas.

## 3.12 Summary of Factors Influencing Viability

We reviewed the potential factors that could be affecting the viability of the eastern black rail. Concerns about the subspecies' status revolved around the following factors: (1) habitat fragmentation and conversion resulting in the loss of wetland habitats across the range of the eastern black rail; (2) altered plant communities, primarily due to fire suppression, changing temperatures, sea level rise, and human modification; (3) altered hydrology resulting in impacts to soil moisture, surface water, sediment and nutrient transport, riparian and wetland vegetation communities, and land subsidence; (4) land management such as wildfire suppression, prescribed fire, grazing, haying and mowing, and impoundments; (5) effects of climate change resulting in increased sea level rise, increased temperatures, decreased precipitation, increased severe weather such as drought, flooding, or storms, and changes in wildfire frequency and intensity; (6) oil and chemical spills and environmental contaminants such as pesticides; (7) disease, specifically West Nile virus; (8) altered food webs resulting from invasive species (fire ants, feral pigs, mongoose, and exotic reptiles) introductions; and (9) human disturbance such as the excessive use of playback calls (black rail vocalizations used to elicit responses from birds).

Historically, the primary stressors to the eastern black rail included habitat degradation and fragmentation from conversion of marshes and wetlands to agricultural lands or urban areas. Also, historical efforts to reduce mosquito populations included marsh draining and ditching, both of which reduced suitable habitat for the eastern black rail. The change of hay harvesting from traditional methods to mechanical methods also lead to habitat degradation and direct mortality of eastern black rails present around these areas. In addition, coastal prairie habitats in Texas were converted to pasture for cattle grazing as well as agriculture (forage, grain crops).

Based on our review of the best available science, we identified current stressors, which are slightly different than historical stressors, influencing the viability of the eastern black rail. Habitat degradation and resulting wetland loss from ditching and draining of marshes for mosquito control is not a current stressor, and conversion of wetlands to agricultural and urban areas has slowed as compared to historically. Currently, the eastern black rail is impacted by the loss, degradation, and fragmentation of wetland habitats resulting from sea level rise along the coast and ground-and surface-water withdrawals across the subspecies' range. Incompatible land management techniques, such as application of poorly timed and planned prescribed fires, intense grazing, or haying, also have negative impacts on the eastern black rail and its habitat, especially when conducted at sensitive times, such as the breeding season or the flightless molt period. Stochastic events, such as flood events and hurricanes, can also have significant impacts on populations of eastern black rail. For example, extensive flooding from Hurricane Harvey was documented at occupied sites of eastern black rail across the Texas coast, and since this flooding occurred during the flightless molt period for the subspecies, the extended period of water on the wetland surface likely impacted the subspecies.

When considering the future risk factors to the eastern black rail, there is likely a complex interaction of factors having synergistic effects on the subspecies as a whole. In coastal areas, sea level rise, as well as increasing storm frequency and intensity and increased flood events (both those associated with high tides and storms), will have both direct and indirect effects on the subspecies. The remaining extensive patches of high marsh required for breeding are projected to be lost or converted to low marsh or open water (as a result of sea level rise). In addition, there will be increasing demands on groundwater withdrawals, which will reduce soil moisture and surface water, and thus negatively impact wetland habitat. Localized subsidence is expected to occur when groundwater withdrawal rates are greater than the aquifer recharge rates. Also, warmer and drier conditions (associated with projected drought increases) will reduce overall habitat quality for the eastern black rail. Incompatible land management (such as untimely prescribed fire application and overgrazing) will continue to negatively impact the subspecies throughout its range, especially if done during sensitive time periods, i.e., the breeding season or flightless molt period.

These stressors contribute to the subspecies occupancy at sites and thus its population numbers. Some stressors have resulted in permanent or long-term habitat loss, such the historical conversion of habitat to agriculture, while other factors may only affect sites temporarily, such as a fire or annually reduced precipitation. Even local but too frequent intermittent stressors, such as unusual high tides or prescribed fire, can cause reproductive failure or adult mortality, respectively, and thus reduce eastern black rail occupancy at a site and the ability of a site to allow for successful reproduction of individuals to recolonize available sites elsewhere. While these intermittent stressors allow for recolonization at sites, recolonization is based on productivity at other sites within a generational timescale for the subspecies. If these stressors, combined, occur at frequencies within and across generations, they could limit the ability of the eastern black rail to maintain occupancy at habitat sites and also limit its ability to colonize previously occupied sites or new sites. It is likely that several of these stressors are acting synergistically on the subspecies, and the combination of multiple stressors may be more harmful than a single stressor acting alone. Although there is some inherent uncertainty surrounding the stressors we evaluated for the eastern black rail and their synergistic effects are largely unknown, this does not prevent us from making a credible assessment of the likely direction and magnitude of those impacts, even though it may not be possible to make such predictions of impacts with precision.

# CHAPTER 4 - POPULATION AND SUBSPECIES NEEDS AND CURRENT CONDITION

In this chapter we consider what the eastern black rail needs for viability. First, we define analysis units to inform the current and future condition of the eastern black rail. We review the conceptual needs of the subspecies, including population resiliency, representation, and redundancy, to support viability and reduce the likelihood of extinction. To conclude the chapter, we consider the current conditions of eastern black rail populations.

## 4.1 Analysis Units

The eastern black rail is a widely distributed, secretive marsh bird with little known about the subspecies' population structure and dynamics. Specific metrics on survival, mortality, lifespan and recruitment are lacking for both the black rail species and eastern black rail subspecies. While there is understanding that the eastern black rail is wetland dependent, as the subspecies occurs in both fresh and estuarine ecosystems, the dynamics of the subspecies' habitat preferences are not completely understood (Schwarzer 2017, pers. comm.). Occurrence data exists for the eastern black rail from specific surveys and citizen scientists; however, this data does not give a clear picture of eastern black rail population structure on the landscape. The scale of analysis for the eastern black rail status assessment therefore depends largely on the scale at which differences exist across the subspecies' range. Since we did not have clear population differentiation for the eastern black rail, we used environmental data and eastern black rail occurrence point data from across the subspecies' range to develop analysis units to inform our analysis of current and future condition. Analyses were performed by the Alabama Cooperative Fish and Wildlife Research Unit.

### *4.1.1 Data Used for Developing Analysis Units*

We collected data points from different sources to assess the eastern black rail across its entire contiguous United States range. We downloaded vetted data from eBird which included historical records, observations from birders, and some more formally collected data (eBird 2017, unpaginated). In addition, the Center for Conservation Biology provided an exhaustive dataset for occurrences in United States coastal states spanning nearly 200 years created by integrating surveys, literature, and museum records (Watts 2016, entire). The University of Oklahoma – Oklahoma Biological Survey also provided a comprehensive dataset for eastern black rail records in the interior United States (Smith-Patten and Patten, 2012, entire); from this dataset, we used the accepted and hypothetical records. Further, 16 research groups and state wildlife agencies shared local monitoring and inventory datasets of eastern black rail collected from across the range. We assessed datasets using different criterion for the analysis unit and occupancy modeling (occupancy modeling is described below in Section 4.2). Latitude and longitude data provided by each research group and state wildlife agency was cross-checked with site identification codes. We visually assessed the proximity of points with identical site identification codes by entering the points' latitude and longitude in the open source geographic information systems program QGIS (QGIS Developement Team 2009, unpaginated). We considered eastern black rail occurrences that occurred within a 200-250 meter radius within a season as a single occurrence (presence point) at a single site in a single year. The radius was applied to the data points to remove spatial autocorrelation to provide a robust dataset for the occupancy modeling. Each point was identified by a unique identification number rather than specific locality for all analyses to ensure privacy of the data.

### *4.1.2 Analysis Unit Approach and Results*

Since there is high spatial and ecological complexity across the range of the eastern black rail, we used a multivariate statistical technique called non-metric multidimensional scaling (NMDS) to account for environmental and biological complexity while designing analysis units. The NMDS has many advantages for complex datasets because it avoids the assumption that eastern black rails associate with the environment in very simple ways, rather it is the complexity of multiple environmental factors that affect eastern black rail occupancy. The relationships of eastern black rail occurrence points are transformed into groups based on environmental variable correlations between the occurrence points using the entire dataset. The NMDS is unaffected by the addition/removal of individual points and the analysis recognizes differences in total abundances to create clusters. We used the cluster groups (i.e., interconnected groups of eastern black rail occurrence points) to create eastern black rail analysis units. See Appendix A for details of the NMDS analysis used to create eastern black rail analysis units for this SSA report.

We used 8,281 point localities from the combined datasets (i.e., eBird, Center for Conservation Biology, University of Oklahoma, and additional research partners) to delineate the analysis units for eastern black rail (Figure 4-1). This total was the result of correcting for autocorrelation of multiple sightings within a day or a small number of days in the eBird dataset and correcting for autocorrelation of sightings at single sites within a single year in the other datasets. The point localities that we did not use were spatially autocorrelated, meaning they were geographically similar to the other points in the combined dataset.

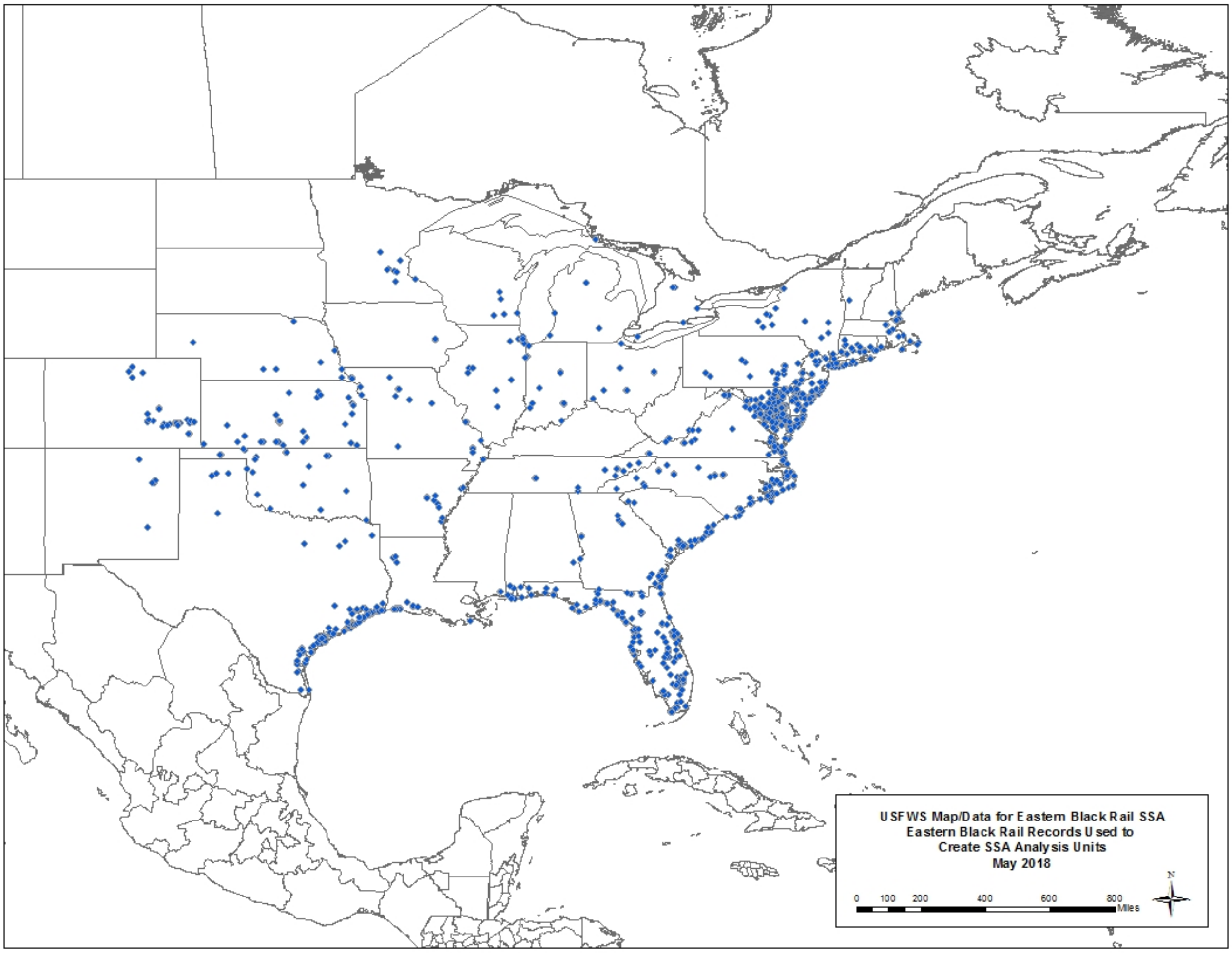


Figure 4-1. Individual eastern black rail (*Laterallus jamaicensis jamaicensis*) records used to help inform analysis unit creation for the Eastern Black Rail Species Status Assessment (SSA). Given the map scale, separate records may overlap, particularly along coastlines. Records indicate individual bird detections. Primary sources: eBird 2017, unpaginated (vetted records only); Smith-Patten and Patten 2012, entire; Watts 2016, entire. Additional data provided by: Audubon Louisiana; Center for Conservation Biology; Clemson University; Florida Fish and Wildlife Conservation Commission; Georgia Department of Natural Resources; Kansas Department of Wildlife, Parks & Tourism; Louisiana Department of Wildlife and Fisheries; Maryland Department of Natural Resources; New Jersey Audubon Society; New Jersey Division of Fish & Wildlife; North Carolina Wildlife Resources Commission; Oklahoma Natural Heritage Inventory; South Carolina Department of Natural Resources; Texas State University – San Marcos; U.S. Fish & Wildlife Service (Ecological Services - North Carolina, South Carolina; Refuges - Region 4 Inventory & Monitoring Program); and Virginia Department of Game and Inland Fisheries.

In order to determine whether individual point observations of eastern black rails correlated with environmental variables, we performed a preliminary collinearity test to examine associations and correlations between environmental variables. This preliminary test was performed on a large candidate covariate dataset finding high redundancy across 37 covariates from 17 standard environmental datasets from the National Land Cover Database (NLCD; Homer et al. 2015, unpaginated), National Hydrography Dataset (USGS 2007-2014, unpaginated), Soil Survey Geographic Database (SSURGO; National Resources Conservation Service [NRCS] 2017, unpaginated), National Climatic Data Center (Young et al. 2017, unpaginated), National Wetlands Inventory (NWI; USFWS 2017a, unpaginated), and National Oceanic and Atmospheric Administration (NOAA; Sweet et al. 2017b, entire). We retained five non-collinear variables for the NMDS analysis (Table 4-1), which were the only environmental covariates without spatial autocorrelation. We included aquifer identification, *aquifer,* which referred to the permeability of the aquifer (USGS); the steepness, *slope*, which was the percent difference between contour elevation lines surrounding the site (Digital Elevation Model [DEM]; NLCD); the average annual *precipitation* and evapotranspiration, *humidity* (NCDC); and the percent of *sand* in the soil at the site (SSURGO) in the final analysis.

We ran the NMDS for 100 iterations and assigned a two axis-score to each point. The best solution was found at the 22$^{nd}$ iteration, which had a stress score of 0.106. Stress scores are calculated to rank solutions when a model converges multiple times; stress $< 0.2$ indicates an appropriate model fit (McCune et al. 2002, entire). The first and second NMDS axes of the best solution were both highly loaded by slope while all other covariates were weakly loaded on the axes (Table 4-2). We then assigned each individual point to a cluster group, identifying five distinct clusters based on the NMDS axes to use as analysis units for the eastern black rail (Figure 4-2, Table 4-3).

Table 4-1. Correlation matrix of the covariates used in a non-metric multidimensional scaling analysis to create analysis units for the eastern black rail.

| Covariate | Aquifer | Slope | Precipitation | Humidity | Sand |
|---|---|---|---|---|---|
| **Aquifer** | 1 | -0.215 | 0.390 | 0.329 | 0.395 |
| **Slope** | | 1.000 | -0.254 | -0.419 | -0.038 |
| **Precipitation** | | | 1.000 | 0.568 | 0.033 |
| **Humidity** | | | | 1.000 | -0.074 |
| **Sand** | | | | | 1.000 |

Table 4-2. The environmental variables used to create analysis units for the eastern black rail, summarized for the entire eastern black rail range in the contiguous United States. Variables were used in a non-metric multidimensional scaling (NMDS) analysis. The NMDS1 and NMDS2 scores of the environmental variables indicate the most influential variables on that axis.

| Covariate | Measure | Min | Max | Units | NMDS1 | NMDS2 |
|---|---|---|---|---|---|---|
| Aquifer | Aquifer permeability | 1 | 7 | Aquifer class (1-7, lowest to highest permeability) | -0.090 | -0.063 |
| Slope | Percent difference between contour elevation lines surrounding the site | 0 | 35 | Percent | 0.455 | 0.228 |
| Precipitation | Mean precipitation | 3.2 | 136.8 | Inches per year | -0.090 | 0.044 |
| Humidity | Mean potential evapotranspiration | 12.8 | 52.7 | Inches per year | -0.042 | 0.047 |
| Sand | Percent sand in soil | 2.5 | 100 | Percent | 0.060 | -0.141 |

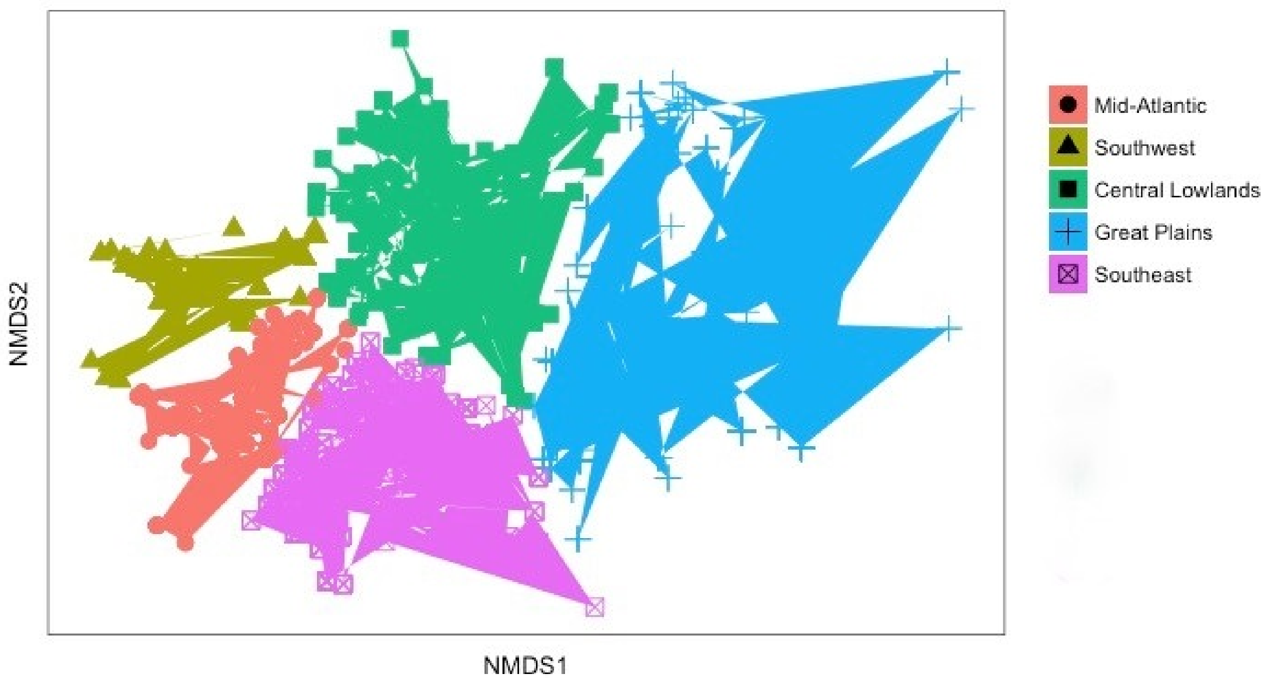


Figure 4-2. Preliminary identification of eastern black rail analysis units using non-metric multidimensional scaling (NMDS). Localities corresponding with data points from years 1980 – 2017 were included in the creation of the analysis units. All eastern black rail localities are associated with environmental covariate data. The NMDS results provided a spatial output that roughly corresponded to the environmental conditions across localities. Both NMDS1 and NMDS2 were strongly influenced by the environmental variable slope (the percent difference between contour elevation lines surrounding a site).

Table 4-3. The environmental variables used to create eastern black rail analysis units, summarized by analysis unit. C. = Central; Precip. = precipitation; SD = standard deviation.

| Analysis Unit | Slope (mean) | Slope (SD) | Precip. (mean) | Precip. (SD) | Humidity (mean) | Humidity (SD) | % Sand (mean) | % Sand (SD) |
|---|---|---|---|---|---|---|---|---|
| Mid-Atlantic | 0.05 | 0.04 | 47.81 | 5.00 | 36.13 | 5.37 | 34.65 | 8.87 |
| Southwest | 0.04 | 0.02 | 50.21 | 3.79 | 42.30 | 2.19 | 15.24 | 2.62 |
| C. Lowlands | 0.99 | 0.80 | 41.52 | 6.64 | 30.21 | 3.80 | 25.20 | 9.29 |
| Great Plains | 1.56 | 1.66 | 20.45 | 13.29 | 28.21 | 2.43 | 33.82 | 9.66 |
| Southeast | 0.23 | 0.20 | 43.18 | 8.67 | 34.17 | 6.04 | 62.45 | 15.87 |

Two areas with historical presence and within the northeastern range of the eastern black rail (before 1980) were identified but not included in the NMDS analysis due to a lack of historical eastern black rail data associated with environmental data. Therefore, we used landscape features, namely the Appalachian Mountain Range and USGS hydrologic units, as well as the boundaries of the analysis units proposed by the NMDS to define two additional analysis units, for a total of seven analysis units. We visually inspected each boundary zone after creating polygons of the analysis units and made adjustments to account for hydrologic, physiographic, and geographic boundaries. We named the analysis units using standard topographic and ecological landmarks as follows: New England, Mid-Atlantic Coastal Plain, Appalachians, Southeast Coastal Plain, Southwest Coastal Plain, Central Lowlands, and Great Plains (Figure 4-3).

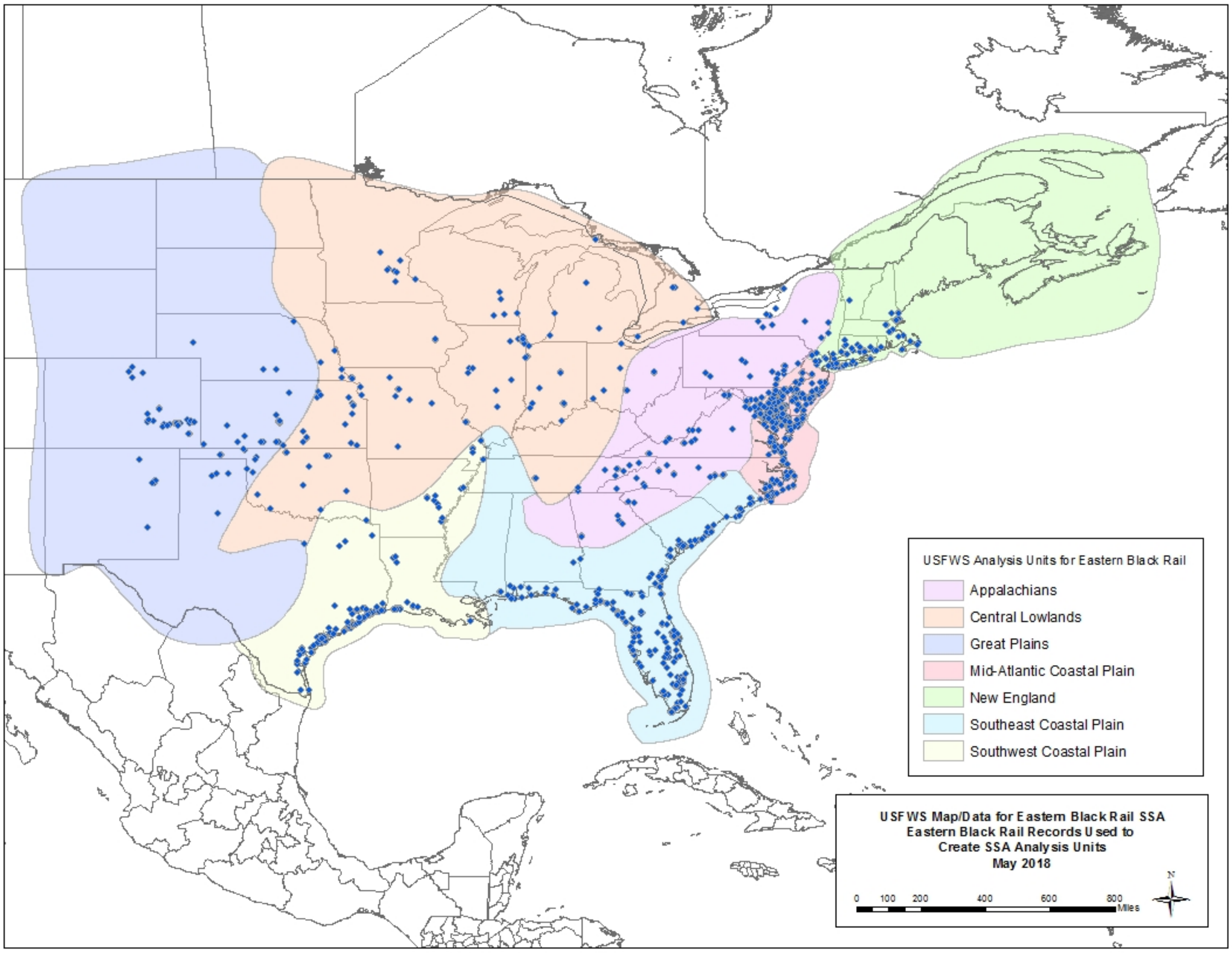


Figure 4-3. Analysis units (color-coded) used in the Eastern Black Rail Species Status Assessment (SSA). Individual eastern black rail (*Laterallus jamaicensis jamaicensis*) records used to help inform analysis unit creation are also shown (blue circles). Given the map scale, separate records may overlap, particularly along coastlines. Primary sources: eBird 2017, unpaginated (vetted records only); Smith-Patten and Patten 2012, entire; Watts 2016, entire. Additional data provided by: Audubon Louisiana; Center for Conservation Biology; Clemson University; Florida Fish and Wildlife Conservation Commission; Georgia Department of Natural Resources; Kansas Department of Wildlife, Parks & Tourism; Louisiana Department of Wildlife and Fisheries; Maryland Department of Natural Resources; New Jersey Audubon Society; New Jersey Division of Fish & Wildlife; North Carolina Wildlife Resources Commission; Oklahoma Natural Heritage Inventory; South Carolina Department of Natural Resources; Texas State University – San Marcos; U.S. Fish & Wildlife Service (Ecological Services - North Carolina, South Carolina; Refuges - Region 4 Inventory & Monitoring Program); and Virginia Department of Game and Inland Fisheries.

## 4.2 Methods for Estimating Current Condition

For the purpose of this assessment, we defined **viability** as the ability of eastern black rail to sustain analysis units in the wild beyond a biologically meaningful time frame. Using the SSA framework, we described viability of eastern black rail by estimating the current condition, and (later) predicting the future condition, of metrics used to assess **resiliency**, **representation, and redundancy** (the 3Rs).

### *4.2.1 Analysis Unit Resiliency*

Given data availability, eastern black rail resiliency was estimated using analysis unit-level occupancy probability. Here we describe the analytical approach to analyzing available data to assess current condition across the range of the eastern black rail in a dynamic occupancy analysis. As mentioned in Section 4.1.1, the Service requested and received data from state and partner agencies throughout the current and historical eastern black rail range. These data ranged in quality from direct surveys specifically targeting eastern black rails with call-broadcast surveys to historical encounter-only records from museum collections to eBird data (eBird 2017, unpaginated).

We focused our attention on the high quality data from repeated presence/absence surveys across the range. These surveys were generally conducted according to the protocols of the North American Marsh Bird Survey (Conway 2011, entire) modified specifically for black rail, and provided breeding-season presence/absence data for use in occupancy modeling (MacKenzie et al. 2002, entire; MacKenzie et al. 2003, entire). Since little is known about migration and wintering behavior, as well as site fidelity, these factors were not considered in our analyses.

With the occupancy analyses, we estimated the probability of eastern black rail presence at a site and related the occupancy probability to environmental covariates of interest. We also estimated the probability of detecting an animal if it was present because detecting animals is usually imperfect. Black rails are an especially elusive and cryptic species (e.g., Conway et al. 2004, entire), and therefore, accounting for detection probability can be especially important (Thompson 2013, entire).

We focused on surveys from each analysis unit (AU) that were repeated across years, so that we could use dynamic occupancy models to estimate site colonization and persistence over time. This requires data collection to occur multiple times per season, for multiple seasons (MacKenzie et al. 2003, entire; Kéry and Chandler 2012, entire). We used data from South Carolina (2014-2017; Roach and Barrett 2015, entire; Hand 2017b, entire) and Florida (2016-2017; Schwarzer 2016, unpublished data; Smith and Wiest 2017, unpublished data) to represent the Southeast Coastal Plain AU, data from Texas in 2015 and 2016 (Tolliver 2017, entire;

Tolliver et al. 2017, entire) to represent the Southwest Coastal Plain AU, and data from Kansas (2005-2008; Hands 2009, entire [survey was for all secretive marshbirds]) to represent the Great Plains AU. We ran AU-specific analyses in order to estimate AU specific parameters for the future projection models (see Section 5.2 Projection Model Development). We had no survey sites from the Mid-Atlantic AU that had sufficient data for use in this analysis, so we applied the results from the Southeast Coastal Plain AU to the Mid-Atlantic AU. We used the package "unmarked" in program R (Fiske and Chandler 2011, entire; R Core Team 2018, unpaginated) to analyze and compare models of dynamic occupancy and link model parameters to environmental covariates (see Table 4-4).

Table 4-4. Environmental covariates used in the occupancy model for eastern black rail.

| Covariate | Citation |
| --- | --- |
| Wettest month precipitation | National Climatic Data Center (Young et al. 2017) |
| Temperature range | National Climatic Data Center (Young et al. 2017) |
| Annual mean temperature | National Climatic Data Center (Young et al. 2017) |
| Coldest month mean temperature | National Climatic Data Center (Young et al. 2017) |
| Fire ants (presence/absence) | United States Department of Agriculture (Korzukhin et al. 2001) |

Covariates focused on precipitation and temperature as potentially important predictors of site extinction probability and site colonization probability. We included the presence/absence of fire ants as a covariate because fire ants have been found to overlap with eastern black rails in the states where fire ants have invaded and are a potential predator and competitor. We compared candidate models to explain variation in model parameters using an Akaike Information Criterion (AIC) analysis, and used the occupancy probability estimates to determine current resiliency for each eastern black rail AU.

### *4.2.2 Subspecies Representation and Redundancy*

Representation reflects a subspecies' adaptive capacity such that measures of genetic and ecological variability capture this metric. For eastern black rail, we used two metrics to estimate and predict representative units that reflect the subspecies' adaptive capacity: 1) habitat variability and 2) latitudinal variability. We do not have information related to genetic diversity for the subspecies.

The eastern black rail exhibits adaptive potential by utilizing similar habitat elements within different wetland types (habitat variability) within analysis units, i.e., higher elevation areas within wetlands with dense vegetation, moist soils, and shallow flood depths (Eddlemanet al. 1988, p. 463; Nadeau and Conway 2015, p. 292). The subspecies is found in salt, brackish, and freshwater wetland habitats, and it requires the same elements listed above in each of these habitat types. Therefore, the subspecies demonstrates a level of adaptive capacity by using different wetland types as long as the required habitat elements are present. Additionally, we used the metric of latitudinal variability to reflect the eastern black rail's wide range across the contiguous United States. To maintain existing adaptive capacity, it is important to have resilient populations (analysis units) that exhibit habitat variability and latitudinal variability to maintain adaptive capacity.

The metric of redundancy reflects a subspecies' ability to remain extant after experiencing extreme catastrophic events. Redundancy is measured by assessing the number and distribution of resilient populations throughout a subspecies' range. Species (and subspecies) that are well-distributed across their historical range are considered less susceptible to extinction and more likely to be viable than species confined to a small portion of their range (Carroll et al. 2010, p. entire; Redford et al. 2011, p. entire). We evaluated the current distribution of eastern black rail analysis units through their present-day spatial locations. To have high redundancy, eastern black rail would need to have multiple resilient analysis units spread throughout its range.

## 4.3 Current Condition Results

### *4.3.1 Analysis Units and Eastern Black Rail Resiliency*

We had sufficient data to model three AUs: Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain. Model selection and parameter estimates varied by AU. See App. Tables B1-B3 in Appendix B for candidate models, model ranking, and parameter estimates for the three modelled AUs.

One of the parameters estimated from the dynamic occupancy model was detection probability. Since the eastern black rail is a small, cryptic marsh bird, estimating the probability of detecting the bird if it is present was important. Model results indicated that detection probability in the Southwest Coastal Plain AU and the Great Plains AU was ~0.25, meaning that when eastern black rails are present at a site, there is a 25% probability of detecting them. In the Southeast Coastal Plain AU, there was support for a year-specific detection probability and detection ranged from 0.09 to 0.53, meaning that when birds were present at a site, they were detected between 9% and 53% of the time, depending on the year. The detection probabilities calculated from our dynamic occupancy models were similar to the detection probabilities estimated for other marsh bird species, including a study of eastern black rails in Florida that calculated a 20% to 50% detection probability (Table 4-5; Legare et al. 1999, p. 119). All other model parameters (i.e., occupancy, colonization, persistence, and extinction probabilities) accounted for the detectability of the eastern black rail.

Table 4-5. Detection probabilities calculated for secretive marsh bird species.

| Marsh Bird Surveyed | Detection Probability | Citation |
|---|---|---|
| Yuma clapper rail | 7% to 40% | Conway et al. 1993, p. 285 |
| Black rail | 20% to 50% | Legare et al. 1999, p. 119 |
| Common moorhen | 21% to 93% | Brackney and Bookhout 1982, p. 231 |
| Virginia rail | 22% to 72% | Glahn 1974, p. 212 |
| American bittern | 30.8% | Conway and Gibbs 2001, p. 20 |
| Least bittern | 25.5% | Bogner and Baldassarre 2002, p. 979 |
| Clapper rail | 65% | Conway and Nadeau 2006 in Conway and Gibbs 2011, p. 405 |
| | | * all in Conway and Gibbs 2011, entire |

The Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain AUs have low resiliency based on the occupancy model results. The results indicated very low occupancy probabilities in each modelled AU; 0.25 in the Southwest Coastal Plain, 0.13 in the Great Plains, and 0.099 in the Southeast Coastal Plain. The estimates appeared to be well estimated since the standard error estimates for most parameters were less than the estimated mean (i.e., the coefficient of variations are less than 1.0). The results also indicated fairly high site extinction probabilities with accompanying low site persistence; 0.31 extinction probability in the Great Plains and 0.61 in the Southwest Coastal Plain. In the Southeast Coastal Plain, there was evidence of year specific extinction, with 2016 being as low as 0.001 and 2014 being as high as 0.57. There was little or no support for any of the models with precipitation or temperature covariates in the Great Plains or the Southeast Coastal Plain. In the Great Plains, there was weak evidence that wet season precipitation influences occupancy dynamics, and in the Southeast Coastal Plain, there was even less support that fire ants influence seasonal occupancy. There was stronger evidence in the Southwest Coastal Plain that temperature played a role in determining eastern black rail occupancy; however, for all three AUs, a null model (a model with no covariates) or a simple, year specific model was the best model or equally as good. For the Southeast Coastal Plain model, we analyzed data from Florida separately from the South Carolina dataset because there were fewer years (only two) to analyze, much smaller sample sizes, and the years of the surveys did not match up entirely with the South Carolina data. Occupancy probability was higher in Florida (0.17, SE 0.065) (SE = standard error). To combine these estimates with the results from South Carolina, we calculated a weighted average of the estimates from the two states, weighting the average by the sample size in each dataset.

The Mid-Atlantic Coastal Plain AU also currently exhibits very low resiliency for eastern black rail. As mentioned in Section 4.2.1, we did not have replicated survey data during the necessary multi-year timeframe to run a dynamic occupancy analysis for the Mid-Atlantic Coastal Plain.

Therefore, we used the results from the Southeast Coastal Plain AU, as well as historical and current occurrence information for the Mid-Atlantic (Section 2.5), to infer the current resiliency of the Mid-Atlantic Coastal Plain AU. Based on recent survey data, the Mid-Atlantic is considered to support fewer eastern black rails and occupied habitat patches than the Southeast. The Mid-Atlantic was once considered the stronghold for the eastern black rail not only in the northeast United States, but for the subspecies' entire breeding range (Watts 2016, p. 22). The highest count ever made for eastern black rail in a single night was over 100 calling birds on June 2, 1954 on the Eastern Shore of Maryland (Stewart and Robbins 1958 in Watts 2016, p. 60). As described in Section 2.5.1.2, survey detections have declined across the state by over 90% since the early 1990s; during Maryland DNR surveys from 1990-1992, 140 individuals were detected, followed by 24 individuals in 2007, and only 8 individuals in 2014 (Brinker 2014, unpublished data in Watts 2016, p. 64). This declining trend is not exclusive to the tidal marshes of Maryland. Overall, eastern black rail has experienced a steep decline over the past century in states within the Mid-Atlantic AU, with an estimated 95-170 breeding pairs remaining (Watts 2016, p. 19). Current estimates of breeding pairs for each state in the Mid-Atlantic AU are: 40-60 pairs in New Jersey and North Carolina, 15-30 pairs in Maryland, 0-10 pairs in Delaware and Virginia, and 0 pairs in the District of Columbia (Watts 2016, p. 19). The uncertainty surrounding these estimates varies from low to moderate; there is moderate uncertainty for states with more extensive marshes that preclude full survey coverage (e.g., New Jersey, Maryland; Watts 2016, pp. 19, 54, 64). Because the Mid-Atlantic AU currently supports substantially fewer birds than the region once did by orders of magnitude, and because it supports fewer birds than the Southeast AU, which is characterized by low resiliency, we conclude that the Mid-Atlantic AU has even lower resiliency than the Southeast AU.

The remaining three AUs, New England, Appalachians, and Central Lowlands, currently demonstrate no resiliency. There were insufficient detections to model these units and recent detections (2011 to present) were fewer than 20 records for each AU. While these three units historically did not support abundances of eastern black rail as high as the other four AUs, an evaluation of current status information yields that eastern black rails are effectively extirpated from portions of the New England, Appalachians, and Central Lowlands AUs that were once occupied. In New England, the subspecies' historical breeding range presumably extended from the Newbury marshes in Massachusetts south along the Atlantic coast (Watts 2016, p. 16). Current survey data suggests that the eastern black rail has experienced a complete range contraction from the historical northern range limit in Massachusetts, approximately 450 km south to Ocean County, New Jersey (Watts 2016, p. 18), and has been effectively extirpated from the New England AU. In 2015, the State of Connecticut concluded that the black rail was extirpated from the State and removed the species from the State's endangered species list (Section 3.10.4; Connecticut Department of Energy and Environmental Protection 2015a, p. 1; Connecticut Department of Energy and Environmental Protection 2015b, pp. 1-24; Huang 2017, pers. comm.).

While the Appalachians and Central Lowlands AUs support less habitat for eastern black rails compared to the more coastal AUs, interior occurrences were more common historically (Figure 2-6). Current population estimates for States with a large area occurring within the boundaries of the Appalachians AU are effectively zero (Watts 2016, p. 19). An estimated 0-5 breeding pairs currently occur in Pennsylvania and no breeding pairs are thought to occur in New York or West Virginia (Watts 2016, p. 19). Birds previously detected in the Appalachians AU were found in small depressional wetlands within active pastures, other freshwater wetlands dominated by cattails, rushes or sedges, and in drainage ditches (Watts 2016, pp. 48, 74). While these wetland types still exist within the AU and may support individuals or a very low-density, scattered population (Watts 2016, p. 48, 74), a substantial amount of habitat has been lost primarily due to the draining of freshwater wetlands for agricultural purposes. Because breeding pair estimates are effectively zero in three states and this likely holds true for the interior portions of the other states within the Appalachians AU (based on few current detections), we conclude that the Appalachians AU for the eastern black rail has no resiliency. Similar losses of habitat have occurred in the Central Lowlands AU and there are currently few detections of eastern black rails across the AU (Figure 2-6). Moreover, the current detections are not consistent from year to year even when habitat appears to remain suitable. Indiana DNR surveys for eastern black rails at multiple sites from 2010-2016 yielded one detection at a single site known to support black rails previously (Gillet 2017, unpublished data). In 2006, only three birds had been reported in Indiana for the past 20 years (Brock 2006, unpaginated).

In summary, eastern black rail AUs have low to no resiliency in the contiguous United States. We have low confidence that eastern black rails maintain sufficient presence in the New England, Appalachians, and Central Lowlands AUs due to recent low numbers of detections and documented extirpations from previously occupied areas. In addition, the Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain AUs have low resiliency due to low occupancy probabilities, while the Mid-Atlantic AU has even lower resiliency and is less viable than the Great Plains, Southwest Coastal Plain, and Southeast AUs. Lastly, resiliency for the international portion of the eastern black rail's range is more uncertain than the contiguous United States; the sparsity of historical and current records, including nest records, suggests that resiliency outside of the contiguous United States is likely low.

### *4.3.2 Current Subspecies Representation Results*

Historically, the eastern black rail had a wide distribution and exhibited latitudinal variability of analysis units. For this SSA, seven analysis units were identified across the geographic range of the eastern black rail. Three of the AUs (New England, Appalachians, and Central Lowlands) currently have no resiliency, and therefore, this latitudinal variability (higher latitudes) has effectively been lost to the subspecies. While these AUs have experienced changes in their respective environments, wetland habitats continue to be present on the landscape and the subspecies was represented in the past. This suggests that the subspecies has a very narrow ecological niche (elevation, vegetation structure, and hydrology) in both time and space and lacks the adaptive capacity to occupy different niche spaces that might be available in wetlands present across the landscape. In addition to the three AUs with no resiliency, three of the AUs have low resiliency and one has very low resiliency across the geographic range. We have no evidence that eastern black rails are dispersing into new areas at a sufficient rate to maintain viability at such a level that counteracts the impacts from habitat loss, sea level rise, or other factors. In fact, eastern black rails show a limited ability to fly long distances during the breeding and wintering seasons; and only a portion of the birds fly long distances during spring and fall migration. Therefore, even though the eastern black rail still technically occurs at varying latitudes, we conclude that the subspecies currently has a low level of representation across its range.

When considering habitat variability, we determined the eastern black rail has a level of adaptive potential by using similar habitats elements (i.e., higher elevation areas within wetlands with dense vegetation, moist soils, and shallow flood depth) within different wetland types within analysis units. Observations of the subspecies indicate that individuals are currently found predominantly near coastal waters in salt and brackish marsh habitats and to a lesser degree in freshwater wetland habitats. However, individuals do require the same habitat elements within each habitat type. Vegetation species and the presence of tidal influence may differ between habitat types, but all suitable habitats have dense vegetation that provides substantial cover. The eastern black rail is a very shallow water wetland adapted bird, occupying the wetland fringe between emergent wetlands and uplands. Birds require these conditions to be present throughout the period when they are present. Individuals are capable of finding new locations, including habitat patches that are ephemeral in nature, that have the required habitat elements (Watts 2018, pers. comm.). However, there may be other factors that are not currently known to us that influence eastern black rail presence, since not all wetland habitats that appear to be suitable are currently occupied (Schwarzer 2017, pers. comm.). There is no genetic data currently available for the eastern black rail. These considerations support our conclusion that the subspecies has some adaptive capacity by using different emergent wetland habitats; however, given the low level of latitudinal representation, the subspecies may be vulnerable to short- and long-term environmental changes.

#### *4.3.3 Current Subspecies Redundancy Results*

Despite having a wide distribution, the eastern black rail currently has a low level of redundancy across its range. We evaluated the resiliency for the seven AUs and determined three have no resiliency, one has very low resiliency, and three have low resiliency (see Section 4.3.1). With the loss of three AUs in the upper latitudes of the range, the subspecies has reduced ability to withstand catastrophic events, such as hurricanes and tropical storms, which could impact the lower latitudinal AUs. Given the lack of habitat connectivity and the patchy and localized distribution, it would be difficult for the subspecies to recover from a catastrophic event in one or more AU. Considering the low to no resiliency for all AUs of the eastern black rail, this supports our conclusion that the subspecies has low redundancy across the entire range.

# CHAPTER 5 – FUTURE CONDITIONS AND VIABILITY

We have considered what the eastern black rail needs for viability and the current condition of those needs (Chapters 2 and 4), and we reviewed the factors that are driving the historical, current, and future conditions of the subspecies (Chapter 3). We now consider what the subspecies' future conditions are likely to be. We apply our future forecasts to the concepts of resiliency, representation, and redundancy, to describe the future viability of the eastern black rail.

## 5.1 Introduction

We used the results of the dynamic occupancy analysis described in Section 4.2.1 to create a stochastic site occupancy, projection model for the Mid-Atlantic Coastal Plain, Great Plains, Southeast Coastal Plain, and Southwest Coastal Plain AUs where the model parameters (initial occupancy, site persistence, colonization) were derived from the data analysis and were linked to environmental covariates, such as land management and land cover change (sea level rise, development, etc.). We used the projection model to predict future conditions of the eastern black rail analysis units under multiple plausible scenarios. We also used the model to explore what rates of habitat loss might lead to stable occupancy dynamics for the eastern black rail analysis units if nearly all current habitat is preserved.

Occupancy simulation models have been used in conservation and management, especially with pond breeding amphibian species, although this model structure is uncommon in avian literature (e.g., (Martin et al. 2011, entire; Heard et al. 2013, entire; Green and Bailey 2015, entire). Generally, avian population models have more detailed demographic data on productivity and survival of individuals, allowing for the application of age or stage structured population viability models (Morris and Doak 2002, entire). In our case, however, we have data on site occupancy from multiple years, across the eastern black rail range, but lack specific demographic rates so a fully stochastic site occupancy projection model was appropriate.

## 5.2 Projection Model Development

We used a model with a Markovian process to predict the number of sites occupied in the future based on the current number of sites occupied. The primary output metric for our model was the mean proportion of sites still occupied at each time step into the future (+/- 95% CI), which we calculated by dividing the number of sites occupied at time *t* by the initial number of sites occupied in each replicate. Reflecting the results of the data analysis, we implemented a favorable year, neutral year, and unfavorable year dynamic for persistence of eastern black rails in the model. The unfavorable years represent extreme events or catastrophic events in a region in a year; the favorable and neutral years represent natural variability in occupancy dynamics. Our current condition occupancy modeling for the Southeast Coastal Plain AU indicated that extinction probability was 0.57 in 2014, 0.49 in 2015 and 0.001 in 2016, so for the projection model, we used a function that first determined whether it was a favorable, neutral, or unfavorable year with ~0.33 probability of each, then drew the annual persistence probability from the appropriate distribution. For the Southwest Coastal Plain and the Great Plains AUs, we did not have support for year dependent models of occupancy which was probably the result of the short time series or small sample sizes. In those analysis units, we used the upper bound of the 95% C.I. on estimated extinction probability to represent favorable years, the mean to represent neutral years and the lower bound of the 95% C.I. to represent unfavorable years.

We conducted all projection modeling using program R (R Core Team 2018, unpaginated), and replicated the simulations 5,000 times to capture variability in each scenario. See Appendix B for further details regarding projection model development.

### 5.3 Scenario Development

We simulated six future scenarios for eastern black rail viability, incorporating functions to account for changes in habitat condition (positive and negative) and habitat loss over time. Five of these scenarios were considered plausible future scenarios; the sixth scenario was exploratory and considered unlikely to occur. The habitat loss function was a simple reduction in the total number of possible eastern black rail sites at each time step in the simulation by a randomly drawn percentage (a beta distributed random variable) that was specified under different simulation scenarios to represent habitat loss due to development (urbanization) or sea level rise. We used the change in “developed” land cover from NLCD 2011 data to derive an annual rate of change in each analysis unit, and we used NOAA climate change and sea level rise projections to estimate probable coastal marsh habitat loss rates; storm surge was not modeled directly (Parris et al. 2012, entire; Sweet, et al. 2017b, entire). In the Great Plains AU, groundwater loss rates were used, instead of sea level rise data, to represent permanent non-urbanization habitat loss in the analysis unit. The overall groundwater depletion rate was based on the average over 108 years (1900-2008) (Konikow 2013, entire). See Table 5-1 for the covariates used in the projection model. In the projection model, these habitat loss functions did not specify the mechanisms for habitat loss, e.g., storm surges or subsidence; rather, the model simply incorporated a stochastically varying amount of habitat lost each year. We did not project into the future for the three AUs with no current resiliency (i.e., New England, Appalachians, and Central Lowlands).

Table 5-1. Covariates used in the fully stochastic projection model for eastern black rail.

| Covariate | Source (Citation) |
|---|---|
| Sea level rise (localized RCP 4.5) | National Oceanic and Atmospheric Administration (NOAA 2017, entire; Sweet et al. 2017b, entire) |
| Sea level rise (localized RCP 8.5) | National Oceanic and Atmospheric Administration (NOAA 2017, entire; Sweet et al. 2017b, entire) |
| Agriculture | National Land Cover Database (Homer et al. 2015, entire) |
| Grazing, Haying | United States Department of Agriculture (USDA 2014, unpaginated) |
| Development | National Land Cover Database (Homer et al. 2015, entire) |
| Wetlands | National Wetlands Inventory (USFWS 2017a, unpaginated) |
| Forest | National Land Cover Database (Homer et al. 2015, entire) |
| Groundwater depletion (rate) | U. S. Geological Survey (Konikow 2013, entire) |

We also incorporated a function to allow for "poor habitat condition" related to land management, fire, and/or agricultural practices that temporarily (annually) affected habitat condition. Using available data, we calculated the mean annual proportion of the land (sites) exposed to cattle, fire, haying, and water management practices in each AU (USDA 2014, unpaginated). We implemented a function to reduce the persistence probabilities at the proportion of sites exposed to those practices. The realized extinction probabilities were calculated as a weighted average of the sites exposed each year to poor land management and sites not exposed, weighted by the proportions randomly generated each year.

For each AU, we ran five basic scenarios that reflected differing levels of sea level rise (or groundwater loss), land management, and the combined effects of both. These future scenarios forecasted site occupancy for the eastern black rail out to 2100 with time steps at 2043 and 2068 (25 and 50 years from present, respectively). We chose 2100 because it is within the range of the available climate change model forecasts and provides us with a long term analysis for the subspecies. Each scenario evaluated the response of the eastern black rail to changes in three primary risks we identified for the subspecies: habitat loss, sea level rise (or groundwater loss), and land management (grazing, fire, and haying). The trend rates of urban development and agricultural development remained the same, i.e., following the current trend, for all five scenarios.

The <u>first scenario</u> evaluated the condition of the eastern black rail if there was a lower rate of habitat loss in the future. The sea level rise projection was taken from RCP 4.5. The level of land management (grazing, fire, and haying) was simulated to be positive, i.e., land management practices will benefit the eastern black rail. We considered the future impacts of drought, extreme weather, wildfire, and groundwater under an RCP 4.5 scenario.

The <u>second scenario</u> evaluated a moderate sea level rise projection under RCP 4.5. The level of land management (grazing, fire, and haying) was simulated to be neutral, i.e., land management practices that were expected to neither benefit or negatively impact eastern black rail. We considered the future impacts of drought, extreme weather, wildfire, and groundwater under an RCP 4.5 scenario.

The third scenario evaluated a high sea level rise projection under RCP 8.5. The level of land management (grazing, fire, and haying) was simulated to be negative, i.e., will have a negative impact on eastern black rail. We considered the future impacts of drought, extreme weather, wildfire, and groundwater under an RCP 8.5 scenario.

The fourth scenario evaluated bad land management (grazing, fire, and haying) for eastern black rail. The sea level rise projection was taken from RCP 4.5. The level of land management (grazing, fire, and haying) was simulated to be negative. We considered the future impacts of drought, extreme weather, wildfire, and groundwater under an RCP 4.5 scenario.

The fifth scenario evaluated the condition of the eastern black rail with the current trend of habitat loss in the future. The sea level rise projection was taken from RCP 4.5. The level of land management (grazing, fire, and haying) was simulated to be positive. We considered the future impacts of drought, extreme weather, wildfire, and groundwater under an RCP 4.5 scenario.

We also used the model (a sixth scenario) to explore what level of habitat loss would result in stable occupancy dynamics for the eastern black rail over time, i.e., what level of reduced habitat loss within the eastern black rail analysis units promote resiliency. We note that sea level rise impacts were not considered in this scenario. The sixth scenario was an exploratory scenario that allowed us to examine the response across the analysis units if nearly all current habitat is preserved. We do not consider this scenario to be plausible without major habitat management intervention.

**5.4 Results and Discussion**

The 5,000 replicates of the projection model predicted high probability of complete extinction for all remaining AUs under all of the primary simulations for each scenario by 2100 (Table 5-2). The Southwest Coastal Plain AU had the longest predicted time to complete extinction, between 45 to 50 years from the present. The Southeast Coastal Plain and the Mid-Atlantic Coastal Plain AUs predicted the time to complete AU extinction is between 35 and 50 years from present depending on the scenario (Table 5-3). The Great Plains had the shortest time to complete AU extinction, between 15 to 25 years from the present depending on the scenario (Table 5-3). The simulations exhibited high variability across the 5,000 replicates (Table 5-2), but generally, after the first approximately 25 years, all scenarios exhibited consistent downward trends in the proportion of sites remaining occupied across most replicates. Most predicted occupancy declines were driven by habitat loss rates that were input into each scenario. The model results exhibited little sensitivity to changes in the habitat quality components in the simulations for the range of values that we explored. For the sixth scenario, which was considered exploratory, our model used a very low habitat loss rate of 0.005, or 0.5% annually. This resulted in fairly stable populations in the coastal AUs (greater than 60% of sites still occupied in 50 years), but still predicted large declines in the proportion of sites occupied in the Great Plains AU. Again, this exploratory scenario did not consider the impacts of sea level rise or groundwater loss, and we did not consider this a plausible future scenario. See App. Figures B1-B6 in Appendix B for graphs of the proportion of sites remaining occupied by eastern black rail over time for all analysis unit and scenario combinations.

Table 5-2. Simulation output for four eastern black rail analysis units under multiple scenarios. The first five scenarios were considered plausible future scenarios. The sixth scenario was an exploratory scenario. The model predicts the proportion of sites likely to remain occupied at 25 years (2043), 50 years (2068), and 84 years (2100) into the future.

| **Mid-Atlantic Coastal Plain** | | | | | |
|---|---|---|---|---|---|
| **Scenario** | **Habitat loss*** | **Habitat quality†** | **25 Years‡** | **50 Years‡** | **84 Years‡** |
| Scenario 1 | 0.1203 | 0.0012 | 0.078 | 0.003 | 0.000 |
| Scenario 2 | 0.1203 | 0.0092 | 0.077 | 0.003 | 0.000 |
| Scenario 3 | 0.1303 | 0.029 | 0.054 | 0.000 | 0.000 |
| Scenario 4 | 0.1103 | 0.029 | 0.070 | 0.003 | 0.000 |
| Scenario 5 | 0.1203 | 0.0002 | 0.079 | 0.003 | 0.000 |
| Scenario 6 | 0.005 | 0.0002 | 1.201 | 1.042 | 0.887 |
| **Great Plains** | | | | | |
| **Scenario** | **Habitat loss*** | **Habitat quality†** | **25 Years‡** | **50 Years‡** | **84 Years‡** |
| Scenario 1 | 0.144 | 0.001 | 0.000 | 0.000 | 0.000 |
| Scenario 2 | 0.153 | 0.009 | 0.000 | 0.000 | 0.000 |
| Scenario 3 | 0.161 | 0.029 | 0.000 | 0.000 | 0.000 |
| Scenario 4 | 0.144 | 0.029 | 0.000 | 0.000 | 0.000 |
| Scenario 5 | 0.153 | 0.000 | 0.000 | 0.000 | 0.000 |
| Scenario 6 | 0.005 | 0.000 | 0.042 | 0.038 | 0.030 |
| **Southwest Coastal Plain** | | | | | |
| **Scenario** | **Habitat loss*** | **Habitat quality†** | **25 Years‡** | **50 Years‡** | **84 Years‡** |
| Scenario 1 | 0.1153 | 0.0012 | 0.103 | 0.005 | 0.001 |
| Scenario 2 | 0.1153 | 0.0092 | 0.102 | 0.004 | 0.001 |
| Scenario 3 | 0.1203 | 0.029 | 0.083 | 0.003 | 0.001 |
| Scenario 4 | 0.1153 | 0.029 | 0.094 | 0.004 | 0.001 |
| Scenario 5 | 0.1153 | 0.0002 | 0.104 | 0.005 | 0.001 |
| Scenario 6 | 0.005 | 0.0002 | 1.397 | 1.232 | 1.034 |
| **Southeast Coastal Plain** | | | | | |
| **Scenario** | **Habitat loss*** | **Habitat quality†** | **25 Years‡** | **50 Years‡** | **84 Years‡** |
| Scenario 1 | 0.1203 | 0.0012 | 0.077 | 0.003 | 0.000 |
| Scenario 2 | 0.1203 | 0.0092 | 0.076 | 0.003 | 0.000 |
| Scenario 3 | 0.1303 | 0.029 | 0.055 | 0.002 | 0.000 |
| Scenario 4 | 0.1203 | 0.029 | 0.070 | 0.003 | 0.000 |
| Scenario 5 | 0.1203 | 0.0002 | 0.080 | 0.003 | 0.000 |
| Scenario 6 | 0.005 | 0.0002 | 1.205 | 1.056 | 0.904 |

*Habitat loss: value of 0 is no habitat loss, value of 1 is all habitat lost.

†Habitat quality: value of 0 is good habitat quality, value of 1 is poor habitat quality.

‡Proportion of sites to remain occupied: value of 0 is no sites occupied, value of 1 is all sites remain occupied.

Table 5-3. Number of years until mean trajectory was modelled to extinction for four eastern black rail analysis units under five plausible future scenarios.

| | Scenarios | | | | |
|---|---|---|---|---|---|
| **Analysis Unit** | **1** | **2** | **3** | **4** | **5** |
| Mid-Atlantic Coastal Plain | 48 | 44 | 39 | 49 | 43 |
| Great Plains | 20 | 15 | 12 | 19 | 17 |
| Southwest Coastal Plain | 51 | 45 | 47 | 48 | 47 |
| Southeast Coastal Plain | 50 | 47 | 46 | 56 | 50 |

### *5.4.1 Modeling Limitations and Weaknesses*

Our model was constructed to predict current and future conditions of eastern black rails throughout their range. While the model may be useful for informing decisions, all models are limited in their utility and inference capabilities. One limitation of our modeling is the data we used to parameterize these simulations. Our assessment of current and future condition is based on the occupancy, colonization, and extinction probabilities estimated using repeated survey data, which relied on adequate site selection for eastern black rail surveys in order for the results to be useful in making inferences about current and future condition. Improper site selection could introduce a bias to model estimates (i.e., decreased occupancy or colonization), and thus lead to a more negative assessment of current and future condition. However, the majority of data used in our modeling efforts were from surveys specifically targeting eastern black rail habitats and sites where eastern black rails had been detected (all survey data except those used for the Great Plains AU). Surveyors used the best available information on eastern black rail habitat preferences and used survey methods similar to the Standardized North American Marsh Bird Monitoring Protocol (Conway 2011, entire), but modified specifically for black rails. Further, Maryland survey data, which were not collected in successive years and so could not be used in our modeling efforts, were data from the same sites surveyed three times over ~25 years (Brinker 2014, unpublished data). Those Maryland sites saw a decline in estimated occupancy from ~0.25 to 0.03, giving credence to the inference that occupancy has declined for eastern black rails in this analysis unit (Mid-Atlantic Coastal Plain).

Data from the Southeast Coastal Plain AU had large sample sizes, good spatial coverage, and adequate time series for estimating the key model parameters, but data from the other analysis units were limited. Detection probability in the Southwest Coastal Plain and the Great Plains was ~0.25 and in the Southeast Coastal Plain AU detection probability ranged from 0.09 to 0.53, meaning that when birds were present at a site, they were detected between 9% and 53% of the time. Because eastern black rail detection probability was low across the range (~0.30 or less on average) which introduces uncertainty into the other model parameters and our ability to investigate and estimate relationships with environmental covariates. Our simulation model, in turn, incorporated significant variability and uncertainty into the projections, which leads to variability and uncertainty in model output and predictions.

The data used to parameterize the environmental stressors, urbanization/sea level rise habitat loss, and habitat quality/land management, were spatially coarse metrics for the effects we were attempting to model. For example, the urbanization rate estimated from NLCD data was based on the entire land area for each analysis unit. Those urbanization rates input into our scenarios may overestimate habitat loss rates because converting wetland to urban land cover may not occur at the same rate as other urbanization conversions. Further, some of the habitat that eastern black rails use are protected as NWRs and other conservation lands that are not at risk of development. However, the estimated urbanization rates are orders of magnitude larger than the 0.005 habitat loss rates that lead to a stable population in three of the four AUs, and further, sea level rise rates alone could lead to greater than 50% loss of occupied sites in 50 years.

Our projection model is also limited by not knowing the current state of occupancy in the landscape. We do not know how many sites are currently occupied, though we estimated the probability of occupancy for the sites surveyed. We devised a modeling approach that had a different number of initial sites occupied across replicates to incorporate our uncertainty on the initial state of the population, and we set the proportion of sites still occupied in the future as our primary model output. This relative metric of future state avoids making specific predictions of future site occupancy.

## 5.5 Summary of Future Conditions and Viability based on Resiliency, Representation, and Redundancy

### *5.5.1 Future Resiliency*

In the current condition, we concluded that three AUs (New England, Appalachians, and Central Lowlands) have no resiliency, and are considered effectively extirpated due to very few recent occurrences throughout these AUs. The Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain AUs were determined to have low resiliency and the Mid-Atlantic AU had even lower resiliency. For future condition, we predicted the proportion of sites occupied in the future based on the current number of sites occupied and used our model to explore what rates of habitat loss might lead to viability of the eastern black rail. In terms of resiliency, the four remaining AUs (Mid-Atlantic Coastal Plain, Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain) have a high probability of extirpation (extinction) under all scenarios by 2100.

The scenarios yielded similar results across the Mid-Atlantic Coastal Plain, Great Plains, Southwest Coastal Plain, and Southeast Coastal Plain AUs with some variation in the time to extinction. However, the difference in the time to extinction among the five plausible scenarios was no greater than 10 years for each AU (Table 5-3). In addition, all AUs generally exhibited a consistent downward trend in the proportion of sites remaining occupied after the first ~25 years for all scenarios. Given that most of the predicted declines in eastern black rail occupancy were driven by habitat loss rates, and future projections of habitat loss are expected to continue and be exacerbated by sea level rise or groundwater loss, resiliency of the four remaining AUs is expected to decline further. We expect all eastern black rail AUs to have no resiliency by 2068, as all are likely to be extirpated by that time. We have no reason to expect the resiliency of eastern black rail outside the contiguous United States to improve in such a manner that will substantially contribute to eastern black rail viability within the contiguous United States portion of the range. Limited historical and current data, including nest records, indicates that resiliency outside of the contiguous United States will continue to be low into the future, or decline if habitat loss or other risk factors continue.

### *5.5.2 Future Representation*

In our current condition analysis, we determined the eastern black rail has three AUs (Great Plains, Southeast Coastal Plain, and Southwest Coastal Plain) with low resiliency and one AU (Mid-Atlantic) with very low resiliency. In addition, with the effective extirpation of three AUs (New England, Appalachians, and Central Lowlands), the latitudinal variability of these AUs has been effectively lost to the subspecies, and therefore, we determined the eastern black rail has a reduced level of representation currently. In terms of habitat variability, we concluded the eastern black rail has some adaptive capacity to changing environmental conditions because it uses similar habitat elements across different wetland types (salt, brackish, and freshwater). In the next 25 years (by the year 2043), the Great Plains AU will likely be extirpated (or effectively extirpated) leading to the loss of the remaining higher latitudinal representative unit for the eastern black rail. In addition to this loss, the three remaining AUs (Mid-Atlantic Coastal Plain, Southwest Coastal Plain, and Southeast Coastal Plain) will likely be lost within the next 50 years. Thus, the eastern black rail will likely have no representation by approximately 2068 (Table 5-3).

### *5.5.3 Future Subspecies Redundancy*

Currently, the eastern black rail has four AUs with some level of resiliency (low and very low) spread throughout its range (Figures 4-1, 4-2). Under current condition, we determined that three of the seven AUs have no resiliency, and therefore, the subspecies is likely extirpated in these AUs resulting in a large range contraction and a current low redundancy for the subspecies. We analyzed the four remaining AUs under future scenarios and determined the eastern black rail will have zero redundancy under all plausible scenarios by 2100. In fact, the Great Plains AU will likely be extirpated in 15 to 25 years leading to further reduction (from a current low condition) in redundancy by 2043 and resulting in only coastal populations of the eastern black rail remaining. By only having coastal AUs remaining (and in even lower resiliency than current condition), this will further limit the ability of the eastern black rail to withstand catastrophic events such flooding from hurricanes and tropical storms. By 2068, we expect all eastern black rail AUs to be likely extirpated.

Although the ultimate source of the widespread decline is not clear and despite that the relative role and synergistic effects of the factors are not quantifiable, the decline in eastern black rail is well documented by a previous status assessment (Watts 2016, entire) and supported by our modeling efforts. More detailed information may improve our knowledge of the subspecies' future viability (e.g., population size and trend information, particularly for the Great Plains AU). However, regardless of the uncertainty associated with the subspecies and the factors affecting its population size, the observed extirpation at sites used by the subspecies is expected to continue.

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## APPENDIX A

Creating Eastern Black Rail Analysis Units

Author: Alabama Cooperative Fish and Wildlife Research Unit
April 2018

**Overview:**

The eastern black rail is a widely distributed marsh bird. The scale of analysis for the eastern black rail subspecies status assessment depends largely on the scale at which differences exist across the subspecies' range. To investigate differences across the subspecies' range and differences in subspecies biology, we used the inherent biologically relevant environmental dissimilarities across the subspecies' range to compute analytical units for the Fish and Wildlife Service's (FWS) species status assessment. We assessed the eastern black rail based on its resource needs outlined in Section 2.4 of the SSA report.

There is high spatial and ecological complexity across the range of the eastern black rail. We used a multivariate statistical technique called non-metric multidimensional scaling (NMDS) to account for environmental and biological complexity while designing analysis units. The NMDS has many advantages for complex datasets because it avoids the assumption that eastern black rails associate with the environment in very simple ways, rather it is the complexity of multiple environmental factors that affect eastern black rail occupancy. The relationships of eastern black rail occurrence points are transformed into groups based on the entire dataset using correlations. The NMDS is unaffected by the additions/removals of individual points, i.e., we can add new data to the dataset. Finally, the analysis recognizes differences in total abundances to create clusters. The groups are used to create analysis units that allow interconnected groups of eastern black rail.

**Methods:**

The NMDS process takes six distinct steps. A matrix of pairwise dissimilarity scores is calculated between every individual point in the data set based on each covariate included by the user. Dissimilarity scores are used to subdivide datasets into the different groups. We used a Bray Curtis distance matrix where each covariate was scaled using a square root transformation. The Bray-Curtis distance produces ordinations that approximate environmental distances and is used widely in ecological modeling. The points are assigned coordinates in multi-dimensional space with a random locality. The iterative process of randomly assigned starting localities serves to allow the dimensionality of the points to vary as well as the multi-dimensional space *k*. The points are normalized using a user-specific axis score. A matrix $D_{i,i}$ is created to store the value of Euclidean distance $\mathfrak{Z}_{i,j}$ between each point in *k*-space. The points are ranked to maximize elements of dissimilarity in ascending order. Each element in matrix $D_{i,k}$ must be in the same order as the dissimilarity matrix, and when that is achieved a 'convergent solution' is arrived upon. The final objective for the NMDS process is more succinctly stated as the most optimal condition of $D_{i,j} > D_{k,l}$ , and $\mathfrak{Z}_{i,j} > \mathfrak{Z}_{k,l}$.

The traditional significance test for the multivariate test compares a set of possible random rankings to the final ranked order of points to calculate a 'stress' score to rank the best models. The 'stress' score rearranges the points to fit a series of regressions between each set of points. The stress measure indicates the intensity of departure from monotonicity. Stress scores are used to differentiate between solutions that are less than optimal, for example if 100 iterations of the model are calculated and the model converges four times, then four solutions are available but the solution with the lowest stress represents the ranking of points that create the most dissimilar ordination of localities for the points. Stress $< 0.2$ indicates an appropriate fit (McCune et al. 2002).

We intended to use sub-groups for 'analysis unit wide' occupancy modeling. Thus we used the program R package "cluster" to partition the resulting ranked point localities (Reynolds et al. 1992, Maechler et al. 2016, R Core Team 2018). We optimized median data points using the NMDS axes and classified the smallest set as central medoids. The medoids are central nexus used to partition the data by assigning points to the medoid that most minimizes the sum of total dissimilarities. The process is called partitioning by medoid (PAM).

The Service downloaded and cleaned eBird data which includes historical records, observations from birders, and some more formally collected data (The Cornell Lab of Ornithology, http://eBird.org). The Center for Conservation Biology provided an exhaustive dataset spanning nearly 200 years created by integrating surveys, literature, and museum records (Watts 2016, entire). Sixteen research groups and state wildlife agencies shared local monitoring and inventory datasets collected across the range for the species status assessment. We assessed datasets using different criterion for the analysis unit and occupancy modeling. Latitude and longitude data provided by each research group was cross-checked with site identification codes. We visually assessed the proximity of points with identical site identification codes by entering the points' latitude and longitude in the open source geographic information systems program QGIS (QGIS Development Team 2009). We included presence points occurring within a 200-250 m radius as a single presence point at a single site in a single year to remove spatial autocorrelation.

We imported all points assigned to units into the open source spatial program QGIS. In QGIS, we used the 'Convex Hulls' function in the geoprocessing vector tools to create polygons around each group of points. We manually contoured the boundaries of each analysis unit using biological data including flyways, physiogeographic data boundaries, and USGS hydrologic units with the 'edit vertex' tool. We checked the units for topology to ensure neither overlaps nor gaps affected polygons after processing. We plotted the cluster analysis and the final analysis unit maps using the R programs 'ggplot2' and 'ggmap' (Wickham 2009; Kahle and Wickham 2013).

**Results:**

We used 8,281 point localities from the combined datasets (i.e., eBird, Center for Conservation Biology, University of Oklahoma, and additional research partners) to delineate the analysis units for eastern black rail. This total was the result of correcting for autocorrelation of multiple sightings within a day or a small number of days in the eBird dataset and correcting for autocorrelation of sightings at single sites within a single year in the other datasets. The point localities that we did not use were spatially autocorrelated, meaning they were geographically similar to the other points in the combined dataset. Each point was identified by a unique identification number rather than specific locality for all analyses to ensure privacy of the data. We performed a preliminary collinearity test on a large candidate covariate dataset finding high redundancy across thirty-seven covariates from seventeen standard environmental datasets from the National Land Cover Database (Homer et al. 2015), National Hydrography Dataset (USGS 2007-2014), Soil Survey Geographic Database (National Resources Conservation Service [NRCS] 2017), National Climatic Data Center (Young et al. 2017), National Wetlands Inventory (NWI, U.S. Fish Wildlife Service 2017), and National Oceanic and Atmospheric Administration (Parris et al. 2012, Sweet et al. 2017). For each of these datasets, the individual eastern black rail localities were plotted and intersected to extract the values of each of these covariates for every individual eastern black rail.

In preparation for the analysis and projections into the future, we collected a variety of data. In the dataset, the National Wetland Inventory loss rates are scaled across 16 physiogeographic regions that vary in size. Of the 10,668 black rail points, 6,421 hit a wetland or deepwater polygon within 50m of the point. The same dataset was intersected with loss numbers representing a five year period averaged across each physiogeographic region. The wetland data were in acres per year and we treated the NWI number as a site characteristic in the occupancy model. The number cannot be aggregated for all black rails. To estimate the impacts from sea level rise, we used the Sweet et al. (2017) sea level rise projections where sea level rise varies by locality. For all NOAA Local Scenarios, we used the RCP 4.5 and 8.5 projections where sea level rise varies from 0.5 m to 2 m (Sweet et al. 2017). To estimate the impacts of agricultural production on eastern black rail, we found estimates for the developments of livestock systems nationally (Thornton 2010).

We retained five non-collinear variables for the NMDS analysis (App. Table A-1). In the final analysis, we included aquifer identification (*aquifer*; USGS), the steepness, *slope* (DEM; NLCD), the average annual *precipitation* and evapotranspiration, *humidity* (NCDC), and the percent of *sand* in the soil at the site (SSURGO). The steepness used is the percent difference between contour elevation lines surrounding the site.

App. Table A-1. Correlation matrix of covariates used in the non-metric multidimensional scaling.

| | **Aquifer** | **Slope** | **Precipitation** | **Humidity** | **Sand** |
|---|---|---|---|---|---|

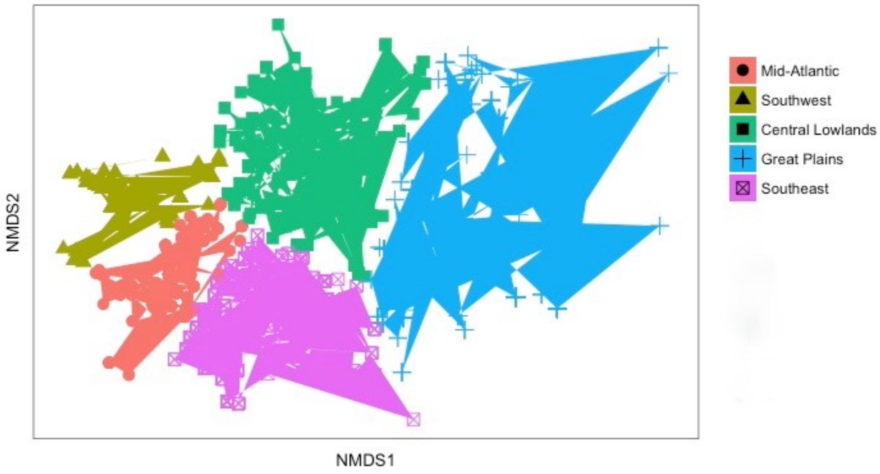
| | | | | | |
|---|---|---|---|---|---|
| **Aquifer** | 1 | -0.215 | 0.390 | 0.329 | 0.395 |
| **Slope** | | 1.000 | -0.254 | -0.419 | -0.038 |
| **Precipitation** | | | 1.000 | 0.568 | 0.033 |
| **Humidity** | | | | 1.000 | -0.074 |
| **Sand** | | | | | 1.000 |

We ran the NMDS for 100 iterations. We assigned a two axis-score to each point. The best solution was found at the 22nd iteration resulting in a stress of 0.106. The first and second axes were both highly loaded by slope while all other covariates were weakly loaded (App. Table A-2). The loading on slope was not further explored for its relationship with eastern black rail abundance or occurrence.

App. Table A-2. The environmental variables used in the covariate analysis summarized for the entire region. The NMDS1 and NMDS2 scores of the environmental variables indicate the most influential variables on that axis.

| Code | Covariate | Min | Max | Units | NMDS1 | NMDS2 |
|---|---|---|---|---|---|---|
| **Aquifer ID** | Aquifer permeability | 1 | 7 | Aquifer class (1-7, lowest to highest permeability) | -0.090 | -0.063 |
| **Slope** | Slope | 0 | 35 | percent slope at the site | 0.455 | 0.228 |
| **Precipitation** | Mean precipitation | 3.2 | 136.8 | inches per year | -0.090 | 0.044 |
| **Humidity** | Mean potential evapotranspiration | 12.8 | 52.7 | inches per year | -0.042 | 0.047 |
| **Sand** | Percent sand in soil | 2.5 | 100 | percent | 0.060 | -0.141 |

We included all points in the PAM process to identify the main clusters. We assigned each individual point to a cluster and imported that data as a text file to identify five corresponding regions to use as analysis units for the eastern black rail (App. Figure A-1, App. Table A-3). The PAM process identified five distinct clusters based on the NMDS axes.



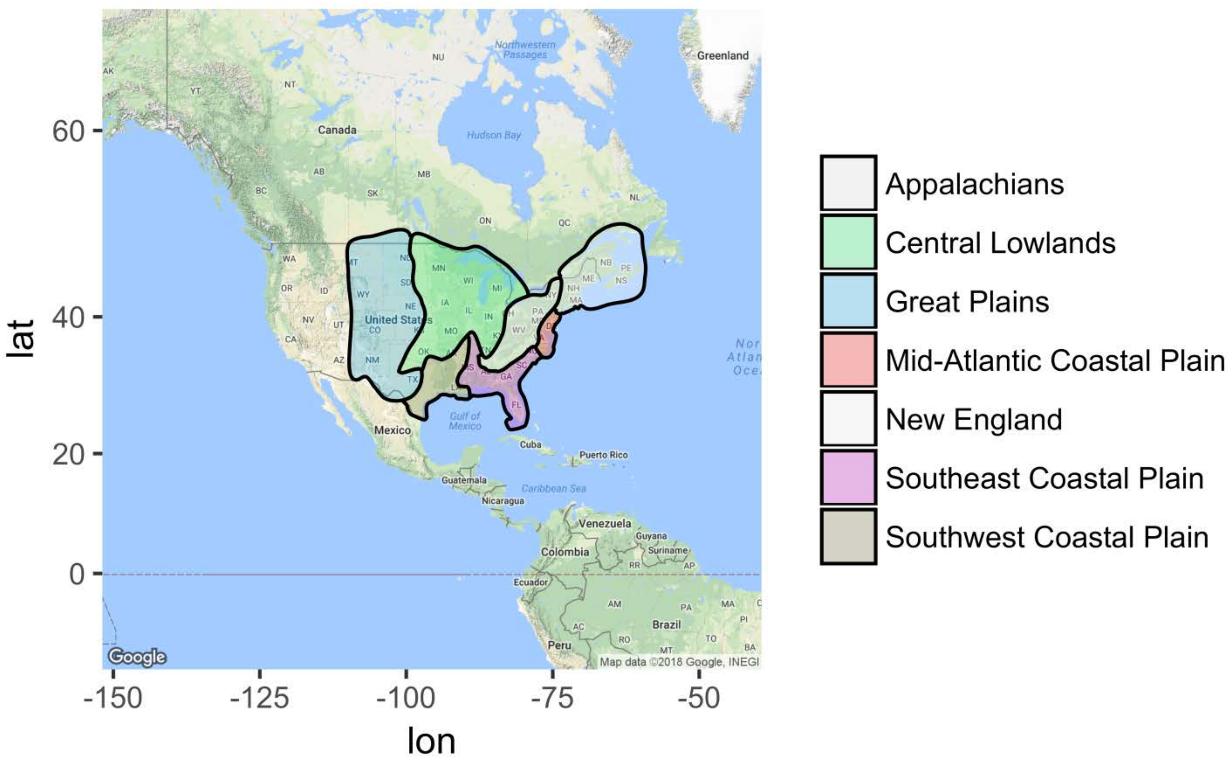

App. Figure A-1. Preliminary identification of analysis units. Individual point observations of eastern black rail from 1980 – 2017 are associated with covariate data. The results of the non-metric multidimensional scaling procedure indicate at least five distinct clusters of eastern black rails. Both NMDS1 and NMDS2 are strongly influenced by slope.

App. Table A-3. The environmental variables used in the covariate analysis summarized by region identified in the PAM cluster analysis.

| **Analysis Unit** | **Mean slope** | **slope (sd)** | **Mean precipitation** | **precipitation (sd)** | **Humidity (mean)** | **humidity (sd)** | **Mean % sand** | **sand (sd)** |
|---|---|---|---|---|---|---|---|---|
| Mid-Atlantic | 0.05 | 0.04 | 47.81 | 5.00 | 36.13 | 5.37 | 34.65 | 8.87 |
| Southwest | 0.04 | 0.02 | 50.21 | 3.79 | 42.30 | 2.19 | 15.24 | 2.62 |
| Central Lowlands | 0.99 | 0.80 | 41.52 | 6.64 | 30.21 | 3.80 | 25.20 | 9.29 |
| Great Plains | 1.56 | 1.66 | 20.45 | 13.29 | 28.21 | 2.43 | 33.82 | 9.66 |
| Southeast | 0.23 | 0.20 | 43.18 | 8.67 | 34.17 | 6.04 | 62.45 | 15.87 |

Two areas with historical presence and within the northeastern range of the eastern black rail (before 1980) were identified but not included in the NMDS analysis due to a lack of historical eastern black rail data associated with environmental data. Therefore, we used landscape features, namely the Appalachian Mountain Range and USGS hydrologic units, as well as the boundaries of the proposed analysis units from the NMDS to define two additional analysis units.

Using standard topographic and ecological landmarks, we named the seven analysis units: New England, Mid-Atlantic Coastal Plain, Appalachians, Southeast Coastal Plain, Southwest Coastal Plain, Central Lowlands, and Great Plains (App. Figure A-2). We visually inspected each boundary zone after creating the polygons and made adjustments to account for hydrologic, physiographic, and geographic boundaries.




App. Figure A-2. Using eastern black rail occurrence data from 1980 – 2017, we determined that five groups of eastern black rails associate with environmentally distinct areas in the Central Lowlands, Great Plains, Mid-Atlantic Coastal Plains, Southeast and Southwest. Historical data prior to 1980 indicate groups of eastern black rails that associate with the Appalachians and New England.

**Considerations of the Current Data from Analysis Units for Occupancy and Projection Modeling (see Appendix B)**

During the data call, the Service received data from researchers investigating the occupancy and distribution of eastern black rail. Despite the final analysis units representing the entirety of the historic and current range of the eastern black rail, current data (2011-2017) was only available from four of the seven analysis units (App. Table A-4). When sorted across the analysis units, we found datasets from more than two consecutive years at replicated sites available within the timeframe of the analysis within three of the analysis units (App. Table A-4). This data was used for the occupancy and projection modeling (see Appendix B) for each analysis unit and was from South Carolina (2014-2017, 396 sites) and Florida (2016-2017, 64 sites) to represent the Southeast Coastal Plain AU, from Texas in 2015 and 2016 (309 sites) to represent the Southwest

Coastal Plain AU, and from Kansas to represent the Great Plains AU (2005-2008; 38 sites). Data reviewed but not included in the occupancy and projection analyses (see Appendix B) either represented single, non-consecutive years, surveys across distinct, non-replicated sites, or was otherwise unavailable at the time (App. Table A-4). The data was submitted as described in SSA section 4.2.1.

App Table A-4. Data provided by research groups and state agencies for use in the eastern black rail species status assessment. Data was reviewed to determine appropriate use in occupancy and projection modeling to determine current and future condition of the eastern black rail. BLRA = black rail.

| **Geographic range** | **Flyways** | **Analysis Unit** | **Replicated Sites with >2 years** | **Type** | **Data** | **Years** | **Uses** |
|---|---|---|---|---|---|---|---|
| TX | Central | Southwest Coastal Plain | Yes | BLRA raw survey data and analyzed data | P/A | 2016-2017 | Not available in digital format |
| TX | Central | Southwest Coastal Plain | Yes | BLRA raw survey data | P/A | 2015-2016 | Used in Appendix B |
| FL | Atlantic | Southeast Coastal Plain | Yes | BLRA raw survey data | P/A | 2016-2017 | Used in Appendix B |
| GA | Atlantic | Southeast Coastal Plain | Yes | BLRA raw survey data | P/A | 2013-2015 | All absence - used initially and later excluded |
| NC | Atlantic | Southeast Coastal Plain | Yes | BLRA raw survey data | P/A | 2014-2015 | Used in Appendix B |
| SC | Atlantic | Southeast Coastal Plain | Yes | BLRA raw survey data | P/A | 2014-2017 | Used in Appendix B |
| VA | Atlantic | Mid-Atlantic Coastal Plain | Yes | BLRA raw survey data | P/A | 2007, 2014 | Not consecutive years |
| NJ | Atlantic | Mid-Atlantic | Yes | BLRA raw survey data | P/A | 2015-2017 | Spatial data incomplete |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Coastal Plain | | | | | |
| MD | Atlantic | Mid-Atlantic Coastal Plain | Yes | BLRA raw survey data | P/A | 1991-1992, 2006-2007, 2014 | Not consecutive years |
| KS | Central | Great Plains | Yes | Marshbird raw survey data | P/A | 2005 - 2008 | Used in Appendix B |
| OK | Central | Great Plains | Yes | BLRA raw survey data | P/A | 2016-2017 | Used in Appendix B |

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# APPENDIX B

Eastern Black Rail Current Condition Analysis and Future Projection Modeling

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April 2018

**Overview:**

Here we describe the analytical approach to analyzing available data to assess current condition of the eastern black rail across the subspecies' range in a dynamic occupancy analysis. We used the results of the analysis to develop a site occupancy projection model where the model parameters (initial occupancy, site persistence, colonization) were derived from the data analysis and were linked to environmental covariates, such as land management and land cover change (sea level rise, development, etc.). We used a fully stochastic projection model to predict future conditions of the eastern black rail analysis units under multiple scenarios. We also used the model to explore what rates of habitat loss might lead to viability for the analysis units and the subspecies.

**Data Analysis for current conditions**:

The Service requested and received data from state agencies and research groups throughout the current and historical eastern black rail range. These data ranged in quality form direct surveys specifically targeting black rails with call back surveys to historical encounter only records from museum collection and eBird data (http://ebird.org/content/ebird/). We focused our attention on the high quality data from repeated presence/absence surveys across the range. These surveys were generally conducted according to the protocols of the North American Marsh Bird Survey (Conway 2011) and provided presence/absence data for use in occupancy modeling (MacKenzie et al. 2002, 2003). With these analyses, we can estimate the probability of presence at a site and relate the occupancy probability to environmental covariates of interest. We can also estimate the probability of detecting an animal if it is present because detecting animals is usually imperfect. Black rails are an especially elusive and cryptic species (e.g., Conway et al. 2004), and therefore, accounting for detection probability can be especially important (Thompson 2013).

We focused on surveys from each analysis unit that were repeated across years, so that we could use dynamic occupancy models to estimate site colonization and persistence over time. This requires data collection to occur multiple times per season, for multiple seasons (MacKenzie et al. 2003, Kery and Chandler 2012). We used data from South Carolina (2014-2017, 396 sites) and Florida (2016-2017, 64 sites) to represent the Southeast Coastal Plain AU, from Texas (2015 and 2016, 309 sites) to represent the Southwest Coastal Plain AU, and data from Kansas (2005-2008, 28 sites) to represent the Great Plains AU. The parameters estimated in these analyses apply to site scale and effective sampling area around each point for the surveys. The specific size of the effective sampling area varies among sites and AUs, but the results effectively apply to a site of 200-250 m radius circles. We ran AU specific analyses in order to estimate AU specific parameters for the future projection models. However, we had no survey sites from the Mid-Atlantic AU that had sufficient data for use in this analysis, so we applied the results from the South East Coastal Plain to the Mid-Atlantic AU. We used the package "unmarked" in program R (Fiske and Chandler 2011, R Core Team 2018) to analyze and compare models of dynamic occupancy and link model parameters to environmental covariates. Covariates focused on precipitation and temperature as potentially important predictors of site extinction probability and site colonization probability. We compared candidate models to explain variation in model parameters using an AIC analysis.

**Results:**

Model selection and parameter estimates varied by region (App. Tables B-1 to B-3).

App. Table B-1. Great Plains candidate models, model ranking and parameter estimates.

| Great Plains Model Selection | | | | | |
|---|---|---|---|---|---|
| Model | nPars | AIC | delta | AICwt | cumltvWt |
| psi(.)gam(.)eps(.)p(.) | 4 | 59.28 | 0 | 0.8774 | 0.88 |
| psi(.)gam(WP)eps(WP)p(Y) | 9 | 64.67 | 5.39 | 0.0592 | 0.94 |
| psi(.)gam(FA)eps(FA)p(Y) | 9 | 66.9 | 7.62 | 0.0194 | 0.96 |
| psi(.)gam(AP)eps(AP)p(Y) | 9 | 66.91 | 7.63 | 0.0193 | 0.98 |
| psi(.)gam(FA+WP)eps(FA+WP)p(Y) | 11 | 68.67 | 9.39 | 0.008 | 0.98 |
| psi(.)gam(Y)eps(Y)p(Y) | 11 | 70.02 | 10.74 | 0.0041 | 0.99 |
| …… | | | | | |
| **Great Plains parameter estimates** | **estimate** | **SE** | **UB** | **LB** | |
| Initial Occupancy (psi) | 0.131 | 0.0747 | 0.277412 | -0.01541 | |
| Extinction (eps) | 0.317 | 0.217 | 0.74232 | -0.10832 | |
| Colonization (gam) | 4.78E-05 | 0.00124 | 0.002478 | -0.00238 | |
| Detection (p) | 0.263 | 0.11 | 0.4786 | 0.0474 | |

App. Tables B-1 to B-3 abbreviations:

| | |
|---|---|
| psi | initial occupancy probability |
| gam | colonization probability |
| eps | extinction probability (Persistence is 1-extinction probability) |
| p | detection probability |
| . | a parameter with no covariates |
| Y | year specific parameter |
| WP | wettest month precipitation |
| AP | Annual precipitation |
| FA | fire ants (presence/absence) |
| RT | Temperature range |

CT coldest month mean temperature
S State (e.g., SC, GA, TX)
MT Annual mean temperature
…… Indicates that additional models were evaluated but we did not include them here because they garnered no support in the analysis.

App. Table B-2. Southwest candidate models, model ranking and parameter estimates.

| Texas (Southwest) Model Selection: | | | | | |
|---|---|---|---|---|---|
| Model | nPars | AIC | delta | AICwt | cumltvWt |
| psi(.)gam(RT)eps(RT)p(Y) | 7 | 721.44 | 0 | 0.54252 | 0.54 |
| psi(.)gam(CT)eps(CT)p(Y) | 7 | 723.44 | 2 | 0.19941 | 0.74 |
| psi(.)gam(.)eps(.)p(.) | 4 | 723.7 | 2.27 | 0.17474 | 0.92 |
| psi(.)gam(FA+RT)eps(FA+RT)p(Y) | 9 | 725.39 | 3.95 | 0.0752 | 0.99 |
| psi(.)gam(AP)eps(AP)p(Y) | 7 | 730.63 | 9.19 | 0.00548 | 1 |

| Southwest parameter estimates | estimate | SE | UB | LB |
|---|---|---|---|---|
| Initial Occupancy (psi) | 0.247 | 0.0481 | 0.341276 | 0.152724 |
| Extinction (eps) | 0.612 | 0.126 | 0.85896 | 0.36504 |
| Colonization (gam) | 0.138 | 0.0419 | 0.220124 | 0.055876 |
| Detection (p) | 0.235 | 0.0415 | 0.31634 | 0.15366 |

App. Table B-3. Southeast candidate models, model ranking and parameter estimates.

| Southeast Model Selection | | | | | |
|---|---|---|---|---|---|
| Model | nPars | AIC | delta | AICwt | cumltvWt |
| psi(.)gam(Y)eps(Y)p(Y) | 11 | 768.01 | 0 | 9.80E-01 | 0.98 |
| psi(.)gam(.)eps(Y)p(Y) | 9 | 776.06 | 8.05 | 1.70E-02 | 0.99 |
| psi(.)gam(FA)eps(FA)p(Y) | 9 | 778.06 | 10.6 | 4.90E-03 | 1 |
| psi(.)gam(FA+Y)eps(FA+Y)p(Y) | 13 | 784.07 | 16.06 | 3.20E-04 | 1 |
| psi(.)gam(S)eps(S)p(Y) | 9 | 800.15 | 32.13 | 1.00E-07 | 1 |
| …. | | | | | |

| Southeast parameter estimates | estimate | SE | UB | LB |
|---|---|---|---|---|
| Initial Occupancy (psi) | 0.099 | 0.007 | 0.112 | 0.086 |
| Extinction (eps) year 1 | 0.570 | 0.165 | 0.893 | 0.247 |
| Extinction (eps) year 2 | 0.490 | 0.114 | 0.713 | 0.267 |
| Extinction (eps) year 3 | 0.001 | 0.044 | 0.087 | 0.000 |
| Colonization (gam) year 1 | 3.80E-02 | 3.20E-11 | 0.038 | 0.038 |
| Colonization (gam) year 2 | 1.00E-08 | 3.12E-06 | 6.13E-06 | 0.000 |
| Colonization (gam) year 3 | 1.90E-19 | 9.62E- | 1.89E- | 0.000 |

| | | | | |
|---|---|---|---|---|
| | | 17 | 16 | |
| Detection (p) year 1 | 0.090 | 0.016 | 0.121 | 0.059 |
| Detection (p) year 2 | 0.530 | 0.049 | 0.626 | 0.434 |
| Detection (p) year 3 | 0.299 | 0.061 | 0.419 | 0.179 |
| Detection (p) year 4 | 0.204 | 0.051 | 0.304 | 0.104 |

The results indicate very low occupancy probabilities in each analysis unit, 0.25 in the Southwest Coastal Plain (App. Table B-2), 0.13 in the Great Plains (App. Table B-1), and 0.099 in the Southeast Coastal Plain (App. Table B-3). The estimates appear to be well estimated since the standard error estimates for most parameters are not excessively large, in other words the coefficient of variation is smaller than the mean. The results also indicate high site extinction probabilities / low site persistence; 0.31 extinction probability in the Great Plains (App. Table B-1) and 0.61 in the Southwest Coastal Plain (App. Table B-2). In the Southeast Coastal Plain, there was evidence of year specific extinction, with 2016 being as low as 0.001 and 2014 being as high as 0.57 (App. Table B-3). There was little or no support for any of the models with precipitation or temperature covariates in the Great Plains or the Southeast Coastal Plain (App. Tables B-1, B-3). In the Great Plains (App. Table B-1), there is weak evidence that wet season precipitation influences occupancy dynamics, and in the Southeast Coastal Plain, there was very weak support that fire ants are determinants of seasonal occupancy (App. Table B-3). There was stronger evidence in the Southwest Coastal Plain that temperature plays are role, but in all analysis units, a null model (one with no covariates) or a simple, year specific model was the best model or equally as good. We analyzed data from Florida separately from the South Carolina data, because there were fewer years (only 2) to analyze from Florida, much smaller sample sizes, and the years of the surveys did not match up with the South Carolina data. Occupancy probability was higher in Florida (0.17, SE 0.065). To combine these estimates with the results from South Carolina, we calculated a weighted average of the estimates from the two states, weighting the average by the sample size in each data set. Detection probability in the Southwest Coastal Plain and the Great Plains was ~0.25 (App. Tables B-1, B-2) meaning that when the birds are present at a site, there is a 0.25 probability of detecting them. In the Southeast Coastal Plain AU, there was support for a year-specific detection probability and detection ranged from 0.09 to 0.53, meaning that when birds were present at a site, they were detected between 9% and 53% of the time (App. Table B-3).

**Projection modeling; predicting future conditions:**

Model description

We used the results of the dynamic occupancy analysis to create a fully stochastic site occupancy, projection model for each of the analysis units. Occupancy simulation models have been used in conservation and management, especially with pond breeding amphibian species, though this model structure is uncommon in avian literature (e.g., Martin et al. 2011; Green and

Bailey 2013; Heard et al. 2013). Generally, avian population models have more detailed demographic data on productivity and survival of individuals, allowing for the application of age or stage structured population viability models (Morris and Doak 2002). In our case, however, we have data on site occupancy from multiple years, across the subspecies' range, but lack specific demographic rates so a fully stochastic site occupancy projection model was appropriate.

Our model used a Markovian process to predict the number of site occupied in the future based on the current number of sites occupied. Our modeling framework is similar to the stochastic patch occupancy model (SPOM) used by Risk et al. 2011 to model western black rail and Virginia rail populations. The future number of sites occupied $N_{t+1}$was a set of Bernnouli trials where the number of trials was the number of previously occupied sites ($N_t$) and the probability of success was the region specific persistence probability estimated in the data analysis described above (1 – eps). In our projection model, site is the same spatial unit (i.e., 200-250 m radius circles) as in the occupancy analysis described above. The process was modeled as:

$N_{i,t+1} = binomial(N_{i,t}, 1 - \varepsilon_{i,t})$, where the number of trials is the previous number of sites occupied ($N_t$) in AU $i$ and ε (extinction probability) is modeled as a stochastic, beta distributed variable where the alpha and beta shape parameters were derived from the estimated mean and variance using the method of moments calculations (Morris and Doak 2002). Because the results support year specific extinction probabilities in the analysis unit where we had the most survey points and the longest time series (South Carolina ~400 survey points visited over 4 successive years), we modeled a process that used a different base distribution for each year depending on whether it was a good year, an okay year, or a bad year. The occupancy analysis, indicated that extinction probability was 0.57 in 2014, 0.49 in 2015 and 0.001 in 2016, so we used a function that first determined whether it was a good, okay, or bad year with ~0.33 probability of each, then drew the annual persistence probability from the appropriate distribution. For the Southwest Coastal Plain and the Great Plains AUs, we did not have support for year dependent models of occupancy which was probably the result of the short time series or small sample sizes. In those analysis units, we used the upper bound of the 95% C.I. on estimated extinction probability to represent good years, the mean to represent okay years, and the lower bound of the 95% C.I. to represent bad years.

The initial number of sites occupied was region specific and was the product of multiplying the total number of possible black rail sites ($U$) in a region by the estimated initial occupancy probability (ψ, psi): $N_{i,t=1} = U_i \times \psi_i$. Psi varied across simulation replicates and was drawn from a beta distribution where the alpha and beta shape parameters were derived from the estimated mean and variance using the method of moments calculations (Morris and Doak 2002). $U$ was set very high in each AU so that the number of sites initially occupied would not be the primary driver of short term AU extinction.

We incorporated a colonization function into the model to allow sites that were not initially occupied or had previously gone extinct, to be colonized. We used a binomial function where the number of Bernoulli trails was the total number of black rail sites available that year and the probability of success was the estimated colonization probability in that region. Colonization probability (γ, gamma) was modeled as a temporally varying parameter and drawn annually from a beta distribution where the alpha and beta shape parameters were derived from the estimated mean and variance using the method of moments calculations (Morris and Doak 2002). Therefore, the full formulation on the $N_{i,t+1}$ model was as follows: $N_{i,t+1} = binomial\left(N_{i,t}, 1 - \varepsilon_{i,t}\right) + binomial(U_{i,t}, \gamma_{i,t})$. The primary output metric for our model was the mean proportion of sites still occupied at each time step into the future (+/- 95% CI), which we calculated by dividing the number of site occupied at time *t* by the initial number of sites occupied in each replicate. We conducted all simulation modeling using MS Excel, and replicated the simulations 5,000 times each to capture variability in each scenario (see below).

Simulation Scenarios

We incorporated functions to account for habitat quality and possible habitat loss over time. The habitat loss function was a simple reduction in *U* at each time step in the simulation by a randomly drawn percentage (a beta distributed random variable) that was specified under different simulation scenarios to represent habitat loss due to development (urbanization) or sea level rise. We used the change in "developed" land cover from NLCD data to derive an annual rate of change in each region and we used NOAA climate change and sea level rise predictions to estimate probable coastal marsh habitat loss rates. In the Great Plain AU, groundwater loss rates were used, instead of sea level rise data, to represent permanent non-urbanization habitat loss in the region.

We also incorporated a function to allow for "poor habitat condition" related to land management, fire, and/or agricultural practices. Using available data, we calculated the mean annual proportion of the land exposed to potentially negative cattle, fire, haying, and water management practices in each region. We implemented a function to reduce the persistence probabilities at the proportion of sites exposed to those practices. The realized extinction probabilities were calculated as a weighted average of the sites exposed to poor land management and sites not exposed, weighted by the proportions randomly generated each year. Annual the persistence probability was therefore modeled as: $\varepsilon_{i,t}^{R} = \left(P(ph_{i,t}) \times \left(\varepsilon_{i,t}^{b} + ph_{i,t}\right)\right) + \left(\left(1 - P(ph_{i,t})\right) \times \varepsilon_{i,t}^{b}\right)$, where $\varepsilon^{R}$is the realized extinction probability in AU *i* at time *t*, *P(ph)* is the proportion of the habitat in poor condition, $\varepsilon^{b}$is the base line extinction probability and *ph* is the poor habitat effect (i.e., the increase in site extinction probability caused by poor habitat). The *P(ph)* value was drawn annually from a beta distribution that was based on the mean and variation estimated from available data and the mean was increased or decreased to represent differing land management scenarios. We did not have data to inform the magnitude of the *ph* factor, so we input a mean of 0.05 increase in extinction probability (which varied annually and was drawn from a beta distribution) and tested the sensitivity of model predictions to changes in the mean *ph* value.

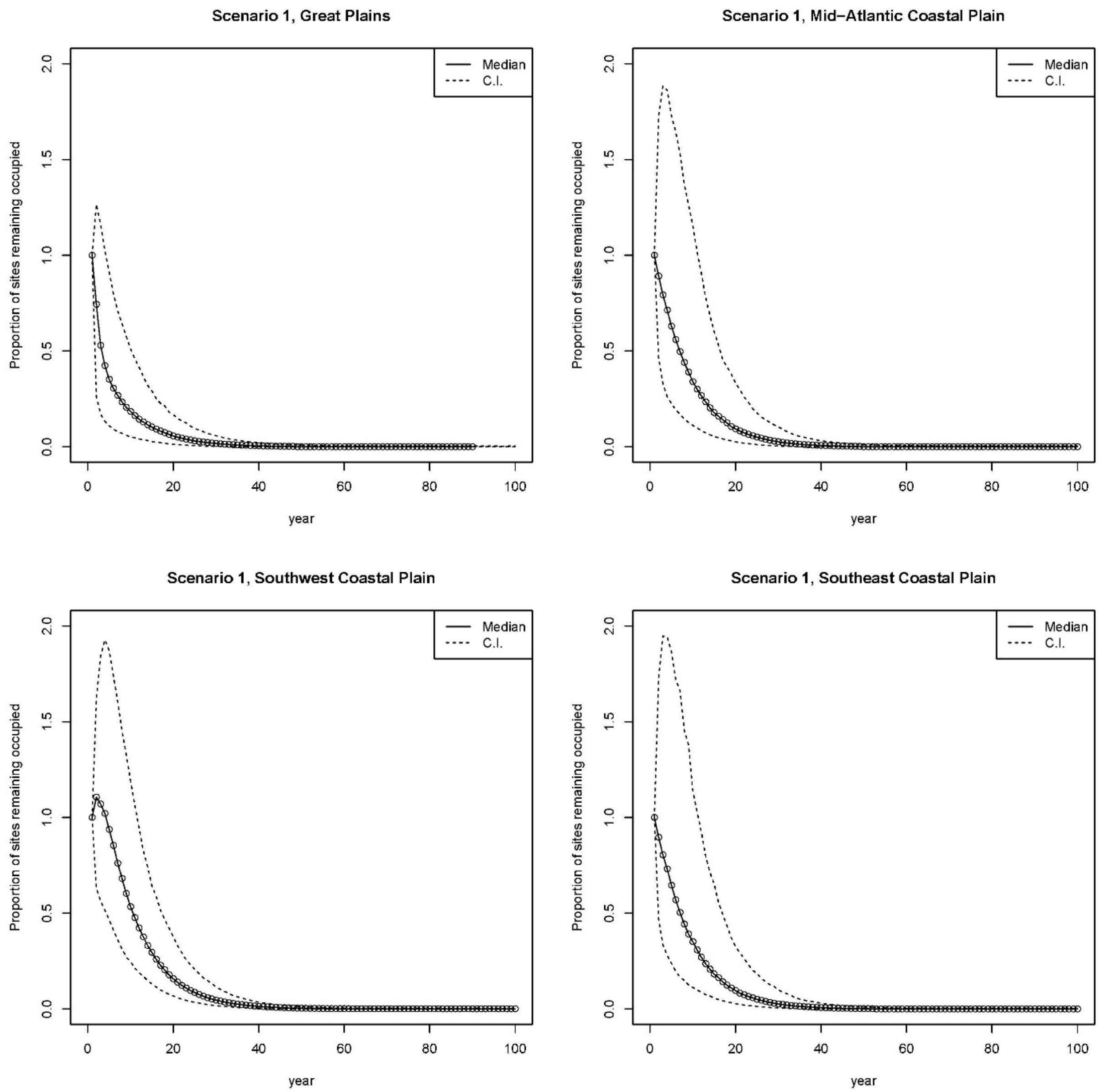
For each AU we ran five basic scenarios that reflected differing levels of climate change induced sea level rise and land management and combined effects of both. We also used the model to explore what level of habitat loss would result in stable occupancy dynamics over time (i.e., what level of habitat loss would the population be resilient to).

**Results:**

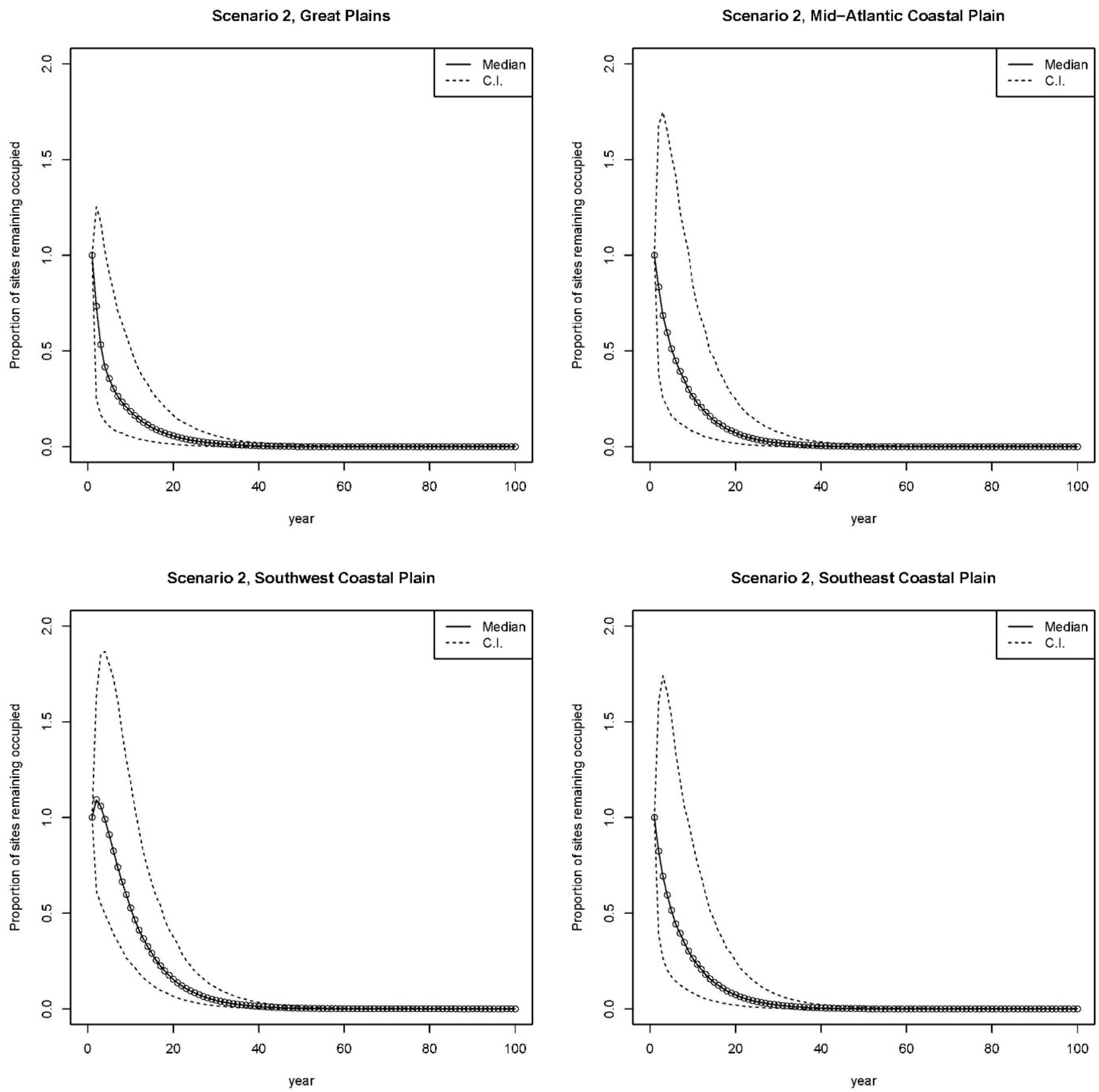
The model predicted high probability of complete extinction for all AUs under all of the primary simulations (App. Table B-4). The Southeast and the Mid-Atlantic AUs had the longest predicted time to complete AU extinction, between 35 and 50 years depending on the scenario (App. Table B-5, App. Figures B-1 to B-5). The Great Plains had the shortest time to complete AU extinction, between 15 to 25 years, depending on the scenario (App. Table B-5, App. Figures B-1 to B-5) and the Southwest AU was in between (App. Table B-5, App. Figures B-1 to B-5). The simulations exhibited high variability across the 5,000 replicates (App. Table B-4, App. Figures B-1 to B-5), but generally, after the first ~25 years all scenarios exhibited consistent downward trends in the proportion of sites remaining occupied across most replicates. Most of the predicted occupancy declines were driven by habitat loss rates input into each scenario. The model results exhibited little sensitivity to changes in the habitat quality components in the simulations (i.e., the *P(ph)* and the *ph* components) for the range of values that we explored. Our model predicts that habitat loss rates of 0.005, or 0.5% annually, would likely result in fairly stable populations in the coastal AUs (>60% of sites still occupied in 50 years), but still predicts large declines in the Great Plains AU.

App. Table B-4. Simulation output for each eastern black rail analysis unit under multiple scenarios. The model predicts the proportion of sites likely to remain occupied at 25 years (2043), 50 years (2068), and 84 years (2100) into the future.

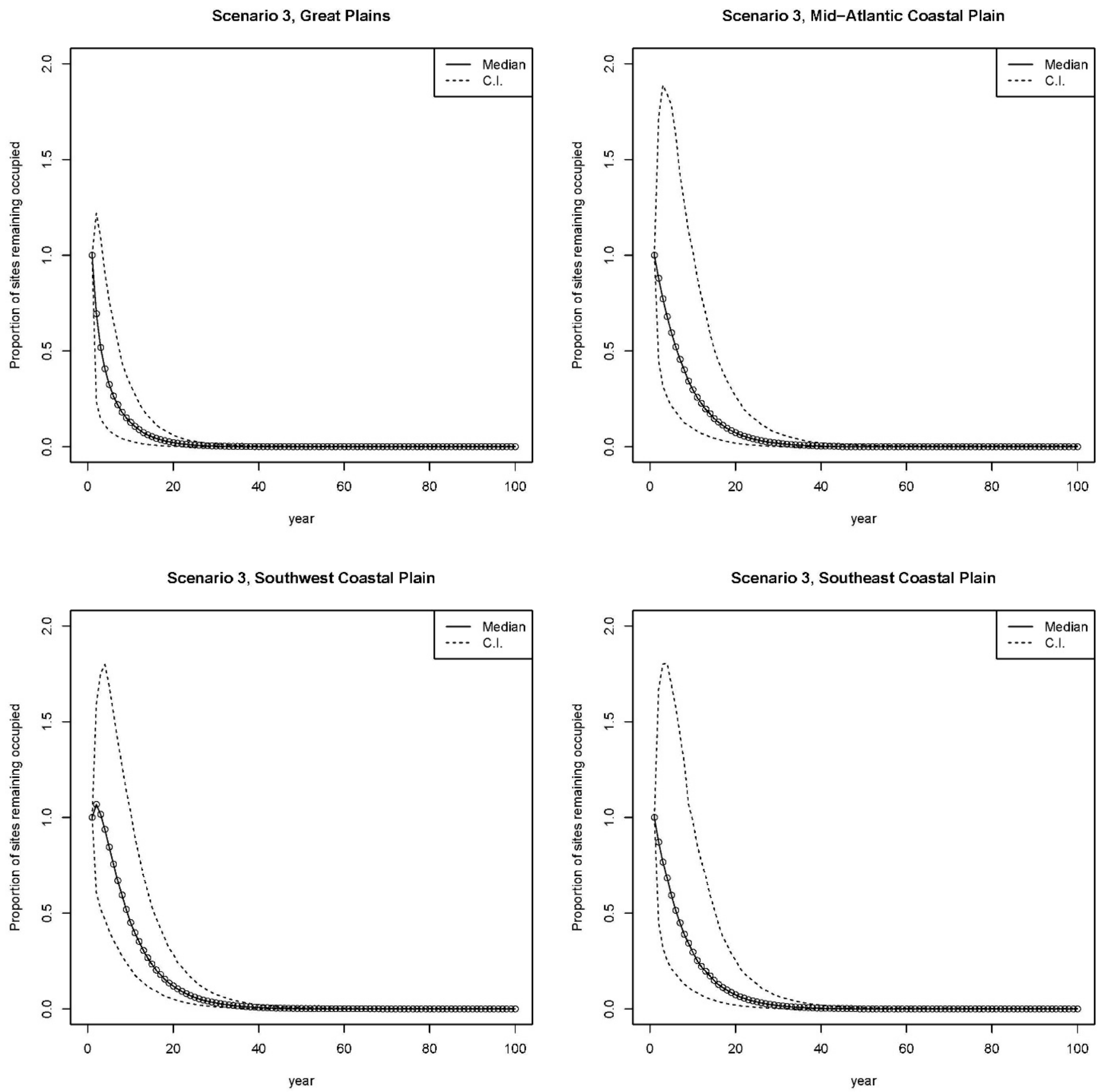
| **Mid-Atlantic Coastal Plain** | | | | | |
|---|---|---|---|---|---|
| **Scenario** | **Habitat loss rate** | **Habitat quality** | **25 Years** | **50 Years** | **84 Years** |
| 1 Lower habitat loss | 0.1203 | 0.0012 | 0.078 | 0.003 | 0.000 |
| 2 Moderate SLR (RCP 4.5) | 0.1203 | 0.0092 | 0.077 | 0.003 | 0.000 |
| 3 High SLR (RCP 8.5) | 0.1303 | 0.029 | 0.054 | 0.000 | 0.000 |
| 4 Bad land management | 0.1103 | 0.029 | 0.070 | 0.003 | 0.000 |
| 5 Good land management | 0.1203 | 0.0002 | 0.079 | 0.003 | 0.000 |
| 6 Preserving nearly all habitat | 0.005 | 0.0002 | 1.201 | 1.042 | 0.887 |
| **Great Plains** | | | | | |
| **Scenario** | **Habitat loss rate** | **Habitat quality** | **25 Years** | **50 Years** | **84 Years** |
| 1 Lower habitat loss | 0.144 | 0.001 | 0.000 | 0.000 | 0.000 |
| 2 Moderate SLR (RCP 4.5) | 0.153 | 0.009 | 0.000 | 0.000 | 0.000 |
| 3 High SLR (RCP 8.5) | 0.161 | 0.029 | 0.000 | 0.000 | 0.000 |
| 4 Bad land management | 0.144 | 0.029 | 0.000 | 0.000 | 0.000 |
| 5 Good land management | 0.153 | 0.000 | 0.000 | 0.000 | 0.000 |
| 6 Preserving nearly all habitat | 0.005 | 0.000 | 0.042 | 0.038 | 0.030 |
| **Southwest Coastal Plain** | | | | | |
| **Scenario** | **Habitat loss rate** | **Habitat quality** | **25 Years** | **50 Years** | **84 Years** |
| 1 Lower habitat loss | 0.1153 | 0.0012 | 0.103 | 0.005 | 0.001 |
| 2 Moderate SLR (RCP 4.5) | 0.1153 | 0.0092 | 0.102 | 0.004 | 0.001 |
| 3 High SLR (RCP 8.5) | 0.1203 | 0.029 | 0.083 | 0.003 | 0.001 |
| 4 Bad land management | 0.1153 | 0.029 | 0.094 | 0.004 | 0.001 |
| 5 Good land management | 0.1153 | 0.0002 | 0.104 | 0.005 | 0.001 |
| 6 Preserving nearly all habitat | 0.005 | 0.0002 | 1.397 | 1.232 | 1.034 |
| **Southeast Coastal Plain** | | | | | |
| **Scenario** | **Habitat loss rate** | **Habitat quality** | **25 Years** | **50 Years** | **84 Years** |
| 1 Lower habitat loss | 0.1203 | 0.0012 | 0.077 | 0.003 | 0.000 |
| 2 Moderate SLR (RCP 4.5) | 0.1203 | 0.0092 | 0.076 | 0.003 | 0.000 |
| 3 High SLR (RCP 8.5) | 0.1303 | 0.029 | 0.055 | 0.002 | 0.000 |
| 4 Bad land management | 0.1203 | 0.029 | 0.070 | 0.003 | 0.000 |
| 5 Good land management | 0.1203 | 0.0002 | 0.080 | 0.003 | 0.000 |
| 6 Preserving nearly all habitat | 0.005 | 0.0002 | 1.205 | 1.056 | 0.904 |



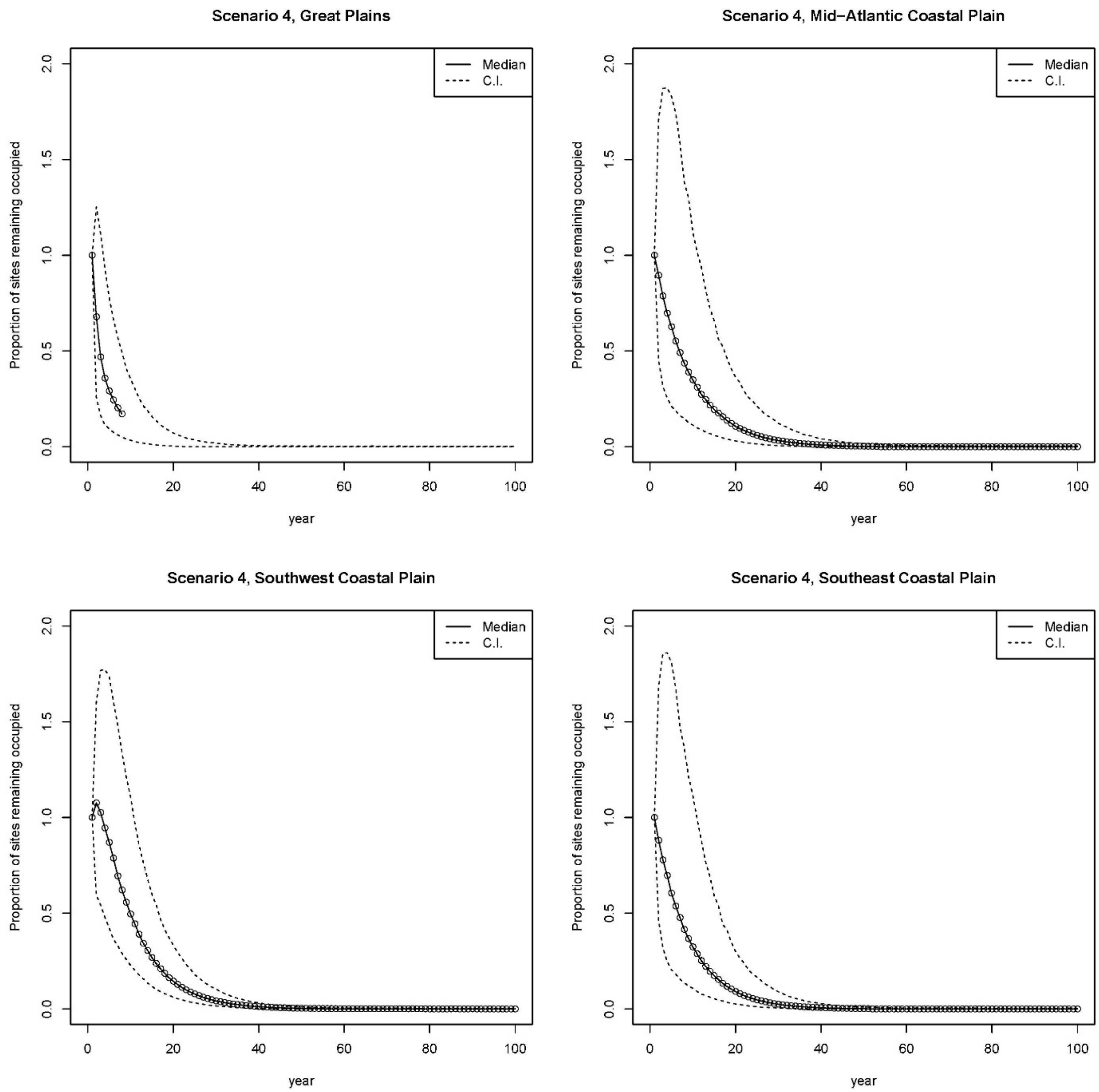

App. Figure B-1. The proportion of sites remaining occupied by eastern black rail over time (+/- 95% CI) in four analysis units under Scenario 1. The X axis starts at 0, which represents present day (2017).



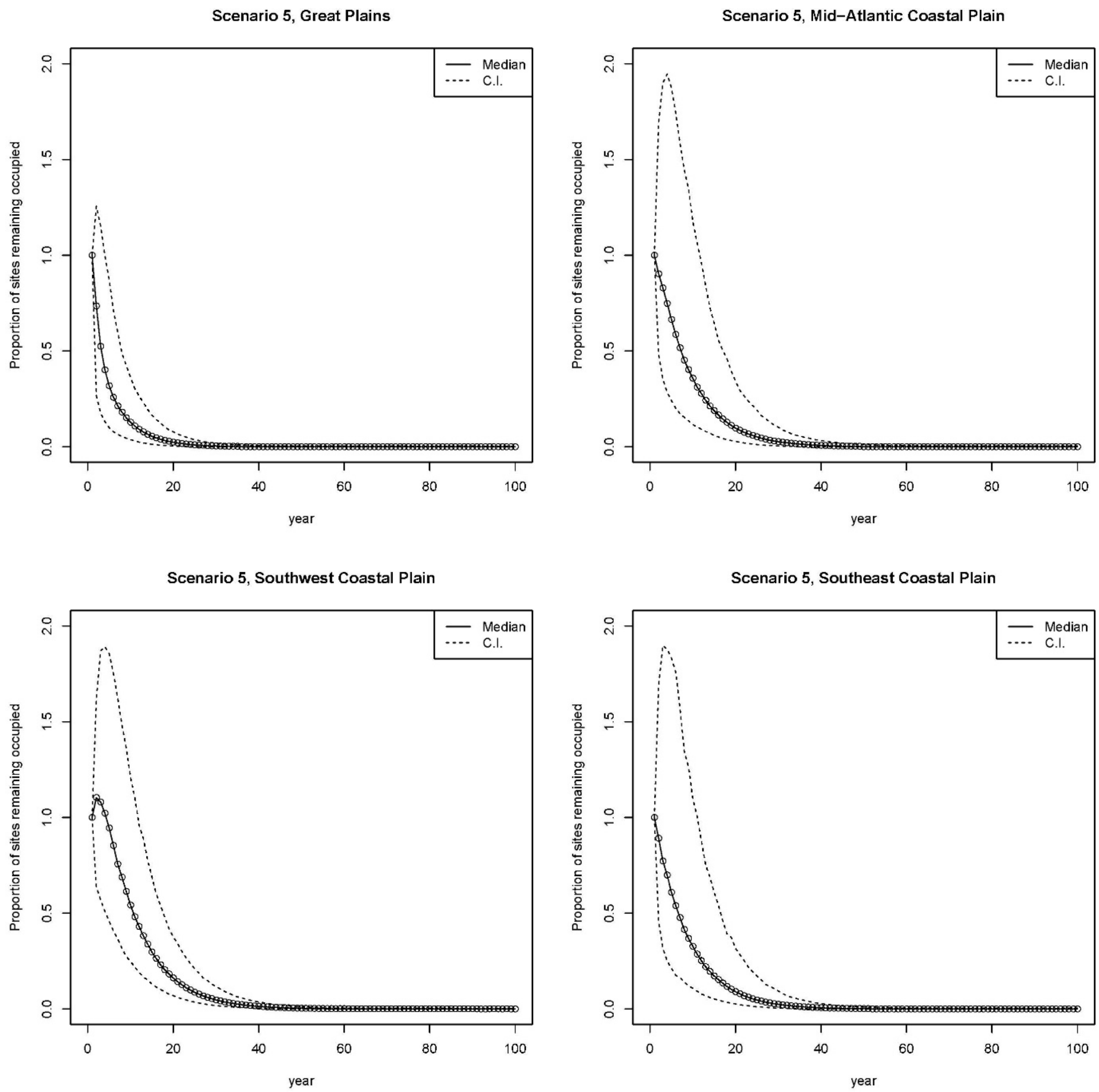

App. Figure B-2. The proportion of sites remaining occupied by eastern black rail over time (+/- 95% CI) in four analysis units under Scenario 2. The X axis starts at 0, which represents present day (2017).



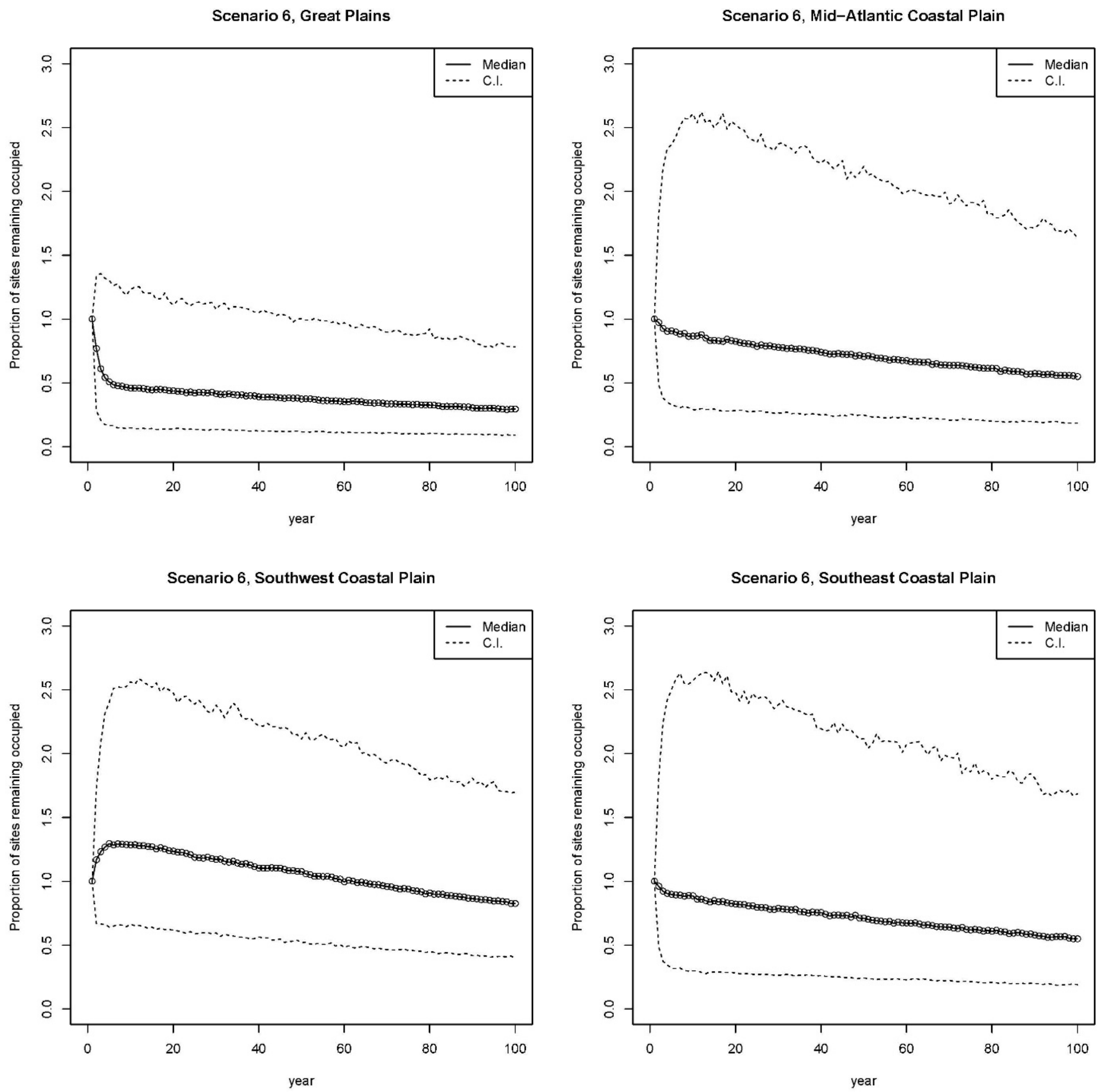

App. Figure B-3. The proportion of sites remaining occupied by eastern black rail over time (+/- 95% CI) in four analysis units under Scenario 3. The X axis starts at 0, which represents present day (2017).




App. Figure B-4. The proportion of sites remaining occupied by eastern black rail over time (+/- 95% CI) in four analysis units under Scenario 4. The X axis starts at 0, which represents present day (2017).




App. Figure B-5. The proportion of sites remaining occupied by eastern black rail over time (+/- 95% CI) in four analysis units under Scenario 5. The X axis starts at 0, which represents present day (2017).




App. Figure B-6. The proportion of sites remaining occupied by eastern black rail over time (+/- 95% CI) in four analysis units under Scenario 6 (exploratory scenario). The X axis starts at 0, which represents present day (2017).

App. Table B-5. Number of years until mean trajectory goes to extinction for each AU under each scenario.

| **AUs** | **Scenarios** | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **Great Plains** | 20 | 15 | 12 | 19 | 17 |
| **Mid-Atlantic** | 48 | 44 | 39 | 49 | 43 |
| **Southwest** | 51 | 45 | 47 | 48 | 47 |
| **Southeast** | 50 | 47 | 46 | 56 | 50 |

Modeling limitations and weaknesses

Our model was constructed to predict current and future conditions of eastern black rails throughout their range. While the model may be useful for informing decisions, all models are limited in their utility and inference capabilities. One limitation of our modeling is the data we used to parameterize these simulations. Data from the Southeast Coastal Plains analysis unit had large sample sizes, good spatial coverage, and adequate time series for estimating the key model parameters, but data from the other analysis units were limited. Eastern black rail detection probability was low across the range (~0.25 or less on average), which introduces uncertainty into the other model parameters and our ability to investigate and estimate relationships with environmental covariates. Our simulation model, in turn, incorporated significant variability and uncertainty into the projections, which leads to variability and uncertainty in model output and predictions. The projection models are entirely dependent on the data used to estimate occupancy and extinction dynamics. If the survey sites that were sampled for eastern black rails were not in optimal habitat, we would likely underestimate initial occupancy and colonization probability and overestimate extinction probability. Those biases would result in overestimating extinction risk for the AUs and the subspecies. However, these are the best available scientific data for use in the SSA, and these surveys were targeted by experts at what is thought to be good eastern black rail habitat; in other words, we used the best available data.

The data used to parameterize the environmental stressors, urbanization/SLR habitat loss and habitat quality/land management, were spatially coarse metrics for the effects we were attempting to model. For example, the urbanization rate estimated from NLCD data was based on the entire land area for each analysis unit. Those urbanization rates input into our scenarios may overestimate habitat loss rates, because converting wetland to urban land cover may not occur at the same rate as other urbanization conversions. Further, some of the habitat that eastern black rails use are protected as wildlife refuges and other conservation lands that are not at risk of development. However, the estimated urbanization rates are orders of magnitude larger than the 0.005 habitat loss rates that leads to a stable population for three of the four analysis units, and further, sea level rise rates alone could lead to greater than 50% loss of occupied sites in 50 years.

Our projection model is also limited by not fully knowing the current state of occupancy in the landscape. We do not know how many sites are currently occupied, though we estimated the probability of occupancy for the sites surveyed. We devised a modeling approach that had a different number of initial sites occupied across replicates to incorporate our uncertainty on the initial state of the analysis unit, and we set the proportion of sites still occupied in the future as our primary model output. This relative metric of future state avoids making specific predictions of future site occupancy.

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