

Management and Monitoring Manual for the Black Rail Adaptive Management Project along the Atlantic Coast

Version 1.2, March 2026



Project Summary

The ACJV and U.S. Geological Survey (USGS), with support from East Carolina University, are engaged with partners in a multi-year collaborative project to develop an adaptive management framework to evaluate two approaches to habitat management for the threatened Eastern black rail (*Laterallus jamaicensis jamaicensis*):

1. Assessing the effect of supplemental irrigation on black rail occupancy.
2. Assessing the relative effects of fire and herbicide for reducing woody vegetation and improving black rail occupancy.

These two topics emerged as priorities during a series of workshops and webinars hosted by the USGS and included land managers, biologists, modelers, and species experts (Lawson et al. 2022). USGS staff then transformed information and expert judgment from partner workshops into statistical models that predicted black rail responses to management actions (Appendices 1 and 2). The next step will be for interested partners to conduct management actions and collect data on bird and habitat responses. Adding data from partner projects can help update and improve statistical models, and more partner data could strengthen conclusions about the effectiveness of these management actions.

This is where you come in! We are seeking land managers that are already conducting prescribed fire or herbicide treatments in black rail habitat or that are interested in trying supplemental irrigation to enhance or create black rail habitat. The first and second chapters of this document provide guidance to managers interested in participating. The remaining chapters provide standardized protocols for monitoring the response of the birds and habitat to management. Though monitoring is an essential feature of this project, we understand that resources for monitoring often are limited. The project can try to assist partners with finding funding for monitoring where necessary. Participation in the project also provides partners an opportunity to share learning and experiences with one another along the way.

If interested, please contact:

Craig Faulhaber – South Atlantic Coordinator, ACJV: craig_faulhaber@fws.gov
Mo Correll – Science Coordinator, ACJV: maureen_correll@fws.gov

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Chapter 1: Manager's Guidance for Irrigation Sites

Welcome

Hello! If you are reading this document, then you are likely a landowner or manager that has a site(s) suitable for irrigation to support black rails and have agreed to or are thinking about participating in our project to create habitat to support this declining, threatened species (85 FR 63764, October 8, 2020). You and/or your partners may already have or are working to secure the resources necessary to manage your sites. Wherever you are in the process, thank you! We recognize it is a big step to carve out space, time and resources for a single species given all the competing priorities in today's world of wildlife conservation and land management.

This document is designed to give managers and their partners a brief overview of the biology and habitat needs of black rails, the context for how this project was developed, and management and monitoring guidelines. In an effort to be as concise as possible, we summarize a lot of information, especially about black rail biology and habitat needs. However, there is an "Additional Resources" subsection at the end of the document with links to additional information. Technical and biological expertise is also always available through the ACJV's Black Rail Working Group (<https://acjv.org/black-rail/>).

Overall, the goal for any irrigation site is to create and maintain suitable conditions for black rails as best as possible for as long as possible. We understand that nature often defies our best laid plans, and that events such as storms, wildfires, equipment failures, etc. are likely to occur and are often beyond our control. We only ask that you attempt what is safe and feasible.

The ACJV Adaptive Management Project

Our project to create habitat through irrigation is part of the Atlantic Coast Joint Venture (ACJV) Adaptive Management Project. This project is co-led by the ACJV and the U.S. Geological Survey (USGS). Together we are trying to learn how to better manage for rails by collecting data on the effects of management activities and using the data to inform future management in an iterative process. The process we use is referred to as "Adaptive Management" and starts with a hypothesis - in this case, the hypothesis is that irrigation can be used to attract and retain rails at a site (depicted in Appendix 1). In scientific terms, we represent it as the following:

Irrigation Hypothesis: Managed water flows that generate appropriate hydrology for Eastern black rails will have a positive effect on occupancy or persistence probability, compared to sites with inappropriate hydrology.

Our goal is to carry out management in a way that will let us test that hypothesis, and then use the data collected to reject or refine that hypothesis "adaptively". The following section outlines how to manage for these conditions, along with some considerations to keep in mind.

Important Conditions and Biological Considerations

Black rails have three main requirements for successful occupancy and breeding: 1) thick vegetative cover, typically dominated by grass-like species; 2) consistent sources of water that are not too deep or

too ephemeral; and 3) variation in topography (i.e., variation and configuration of elevation within a site). Although these habitat requirements are important year-round for black rails, they are especially important during the breeding season (83 FR 50610, October 9, 2018). One of the first steps for participation in this project is to become familiar with the timing of breeding in your area (Table 1.1). Sites selected for this project should already have appropriate vegetative cover and topography but need addition of water to maintain appropriate hydrology. See also the “Additional Biological Information” section (Appendix 3) for an expanded discussion on these three requirements.

Table 1.1. Estimated Eastern black rail (*Laterallus jamaicensis jamaicensis*) breeding season dates by state.

State	Start Date	End Date
Florida		
<ul style="list-style-type: none"> ● Everglades (area from Lake Okeechobee south) ● North and central interior, Gulf Coast saltmarsh 	16 Feb 16 Apr	30 Jun 31 Aug
South Carolina	16 Apr	31 Aug
Georgia	16 Apr	31 Aug
New Jersey	16 Apr	15 Jul
North Carolina	1 May	31 Jul
Virginia	1 May	31 Jul
Maryland	1 May	31 Jul

Management Guidelines

Site Selection

To explore the effects of irrigation on black rails, we are looking to pair treatment and control sites that are relatively close to one another and with similar vegetation types and structure, microtopography, soil type, and distance to a source population of black rails, but that do not have adequate water consistently across the breeding season. One site will act as a control, remaining unchanged from current management conditions, and the other will act as a treatment site where irrigation can be added or changed to provide appropriate hydrology. For this experiment, appropriate hydrology is defined as at least half of the site having moist soil to ~1.5 in. (4 cm) of water depth for the majority (>80%) of the breeding season (see Table 1.1 for the breeding season seasonal window for your area). In scientific terms, we represent it as the following:

Percentage of the days within the breeding season when at least 1.25 ac (0.5 ha) of continuous area is moist soil to ~1.5 in. (4 cm) deep in a 2.5 ac (1 ha) plot; breeding season is defined by arrival of breeding adults (or commencement of breeding activities in places where residency is year-round) until the time chicks are independent.

Considerations for Site Selection

- When selecting sites for treatment, consider distance to and type of water source. Closer proximity to a water source will likely reduce cost and logistical challenges. For more on water sources see the discussion on irrigation infrastructure below.
- For slope wetlands, consider water flow direction and drainage before installation. Avoid flooding or draining onto unsuitable areas including roads, waterways, other properties, etc.
- Consider downstream or aquifer usage that may affect other water uses. Ideally, sites should be no smaller than 2.5 ac (1 ha).

- The site must be dominated ($\geq 51\%$) by herbaceous vegetation at least ~ 16 in. (40 cm) in height on average to provide cover from predators and have $< 10\%$ woody vegetation (i.e., shrubby vegetation or trees). Vegetation can be wetland or upland species but should be dominated by grasses. Ideally, the site edge should also be $\geq \sim 330$ ft. (100 m) from the nearest tree line.
- There are two scenarios where sites have appropriate microtopography for black rails. First, a relatively flat area with little overall slope can contain features such as humps, ripples, moguls, etc. that provide higher elevation areas for nesting and refugia. Second, a sloped area can be shaped in a way that provides varying water depths, with upslope areas available for nesting and refugia. Slopes should ideally be $\leq 2^\circ$ but may be acceptable up to 10° .
- Any soil suitable for small wetland development is appropriate.
- For slope wetlands, consider whether additional sediment transport will occur and where deposition will happen. Although the plants in the wetland may prevent much sediment transport, it is important to consider and to understand that the higher the slope the more likely sediment transport will occur.
- Consider whether there are any materials in the soil that may inhibit plant growth or harm invertebrates such as residual herbicides, pesticides, salts, contaminants, etc.

Types of Irrigation Infrastructure

There are two primary types of irrigation infrastructure that can be used to distribute water to treatment sites.

- Gravity-fed systems are appropriate when the water source is located upslope from the treatment site and generally work better when the treatment site itself is also sloped. Gravity-fed systems are usually passive and offer less control over water levels, although systems can be equipped with water control mechanisms such as valves.
- Pump-fed systems rely on electrical energy to move water from source to site. Although these systems are generally more expensive than gravity-fed systems and require both a source of power and greater maintenance, they offer finer control as well as opportunities for irrigation at sites where gravity-fed systems are not appropriate. Pumps are useful when the slope between the water source and the treatment site is flat, the treatment site is higher than the water source, the water source is groundwater, or the site is far from the water source.

Before selecting an irrigation system, the spatial relationship between the water source and the treatment site should be considered, as well as the amount of water the site will require to maintain appropriate hydrology. To estimate this, consider 1) the amount of water sufficient to cover approximately half the treatment site to ~ 1.5 in. (4 cm) deep, and 2) the evaporation and soil percolation rates. Use these quantities to then calculate the necessary daily flow rate to maintain the water depth during the breeding season (Table 1.1). Flat wetlands may require less water as you may not need to maintain constant flow but rather issue regular pulses to keep up with drainage and evaporation rates. Flow rates between 50-100 gal/min are generally required to maintain new wetlands of the size this project is attempting to create.

Once you have calculated the needed daily flow rate, select the best irrigation system for your site that will allow for up to double the estimated flow rate in the event of extreme dry weather events/droughts. Pay close attention to pipe gauge and pump capacity when choosing a system. Consult an irrigation specialist or contact your state's black rail Working Group or Atlantic Coast Joint Venture staff if you have questions about particular equipment specifications.

Considerations for Choosing an Irrigation System

- **Type of water source** - is it a farm pond, stream, river or groundwater?
- **Distance and slope between water source and treatment site** - how far does the water have to travel and is the water source upslope or downslope from the treatment site?
- **Estimated flow rate needed to maintain appropriate hydrology** - consider selecting equipment with a maximum flow rate higher than the estimated need, because running systems at maximum capacity for long periods of time can wear out equipment faster.
- **Refill rate of the water source** - will the water source refill or stay at appropriate levels for the daily flow rate needs?
- **If using a pump, determine the power source** - is there an electrical source nearby or will you need an alternate power source (e.g., solar panels)?
- **Cost** - while upfront cost is often one of the largest factors in equipment selection, consider the costs of future maintenance as well when selecting equipment.

Irrigation Operation

Once the irrigation system is selected, it needs to be installed and operated. Operation should be done in a way that maintains appropriate hydrology throughout the breeding season, if not year-round. Water levels at the site should be checked frequently and when levels are outside of the desired conditions for more than a few days, steps should be taken to change water flow amounts. Managers are also encouraged to proactively decrease or stop water flows immediately before heavy rains to reduce flooding potential. More information on how to monitor hydrology can be found in the monitoring section below. The key point is to prevent the water depth from flooding out nesting black rails or water depths becoming so low that the wetland becomes small or dries up completely.

Considerations for Installation and Operating an Irrigation System

- Set up and maintain a way to measure water depth. Check water levels at regular, weekly intervals and before and after large weather events.
- System maintenance should be completed before or after the breeding season if possible to avoid disruptions during the breeding season.
- Consider whether additional vegetation management will be necessary and if so, how that will be achieved. With the addition of water, undesirable species may occur such as invasives or shrubby species. These types of plants will need to be reduced or removed.
- Consider the land use of the surrounding area. In areas with livestock or other such activities, measures such as fencing may be necessary.

Required Monitoring

Biological and Physical Measures

Both the treatment and control sites should be monitored for hydrology, vegetation, and black rails. We have developed specific protocols for each of these (Chapters 3-5). Monitoring can be conducted by those managing the site or through collaboration with others; however, it is important that the manager have access to real time hydrology data at the site to manage it effectively. If a contractor or other third party is leading the site monitoring, good communication with the manager and access to the hydrology data should be ensured. We expand on the considerations about monitoring hydrology below because of its direct connection with the management activities.

Considerations for Monitoring Hydrology

- Hydrology should be monitored at several different locations throughout the treatment area to

measure how water flow influences the entire wetland.

- A staff gauge at or near the discharge point for the irrigation system should only be used for management if there is a clear understanding of how depths at this location relate to other locations in the wetland. We suggest releasing water prior to the breeding season to measure and understand this relationship.

Measuring Time and Resources Used

Understanding the cost in time, salary and physical resources for management and monitoring is important because it can affect the willingness of partners to participate. Once a site is enrolled in the project, we (ACJV) will send the appropriate manager or contact person a quarterly questionnaire with 5-7 questions relating to the amount of personnel time and salary and out-of-pocket expenses they and their staff invested in the project. The questionnaire is designed to be simple and short, taking hopefully no more than 5-10 minutes each time. The form will also provide the opportunity to report on any major natural disasters or equipment failures that drastically alter the wetland either temporarily, such as major unpreventable flooding or extensive dry-down, or permanently.

Additional Resources

Financial support for monitoring and management is important and ACJV staff are available to help to obtain those resources as needed. Please reach out to their staff if you need this type of assistance.

Chapter 2: Manager’s Guidance for Fire and Herbicide Treatments

Welcome

Hello! This document is for landowners or managers that have a site(s) suitable for supporting black rails that also currently receives or will receive vegetation management (through fire, herbicide or both). Perhaps you have agreed to or are thinking about participating in our project to maintain habitat to support this declining, threatened species (83 FR 50610, October 9, 2018). We recognize it is a big step to carve out space, time and resources for a single species given all the competing priorities in today’s world of wildlife conservation and land management. Thank you for the consideration!

This document is designed to give a brief overview of the biology and habitat needs of black rails, the context for how the project was developed, and the resulting project management and monitoring guidelines. To be concise we summarize much of the information about black rail biology and habitat needs. However, there is an “Additional Biological Information” section at the end of the document (Appendix 3), and technical and biological expertise is also always available through the ACJV’s Black Rail Working Group (<https://acjv.org/black-rail/>).

Overall, the goal for any site is to maintain suitable conditions for black rails for as long as possible. We understand that nature often defies our best laid plans, and that events such as storms, wildfires, equipment failures, etc. are likely to occur and are often beyond our control. We only ask that you attempt what is safe and feasible.

The ACJV Adaptive Management Project

Our project is designed to determine which method of vegetation management - prescribed fire, herbicide or both - is better at maintaining black rail habitat. This project is co-led by the ACJV and the U.S. Geological Survey (USGS). Together we are trying to learn how to better manage for rails by collecting data on the effects of management activities and using the data to inform future management in an iterative process. The process we use is referred to as “Adaptive Management”, and starts with a hypothesis - in this case, the hypothesis is that fire is the better tool for maintaining rail habitat (depicted in Appendix 2). In scientific terms, we represent it as the following:

Fire vs. Herbicide Hypothesis: Maintaining an appropriate fire regime is more effective than herbicide treatments at minimizing woody encroachment into wetlands with appropriate hydrology for Eastern black rails.

Our goal is to carry out management in a way that will let us test that hypothesis, and then use the data collected to reject or refine that hypothesis “adaptively”. The following section outlines how to manage to test this hypothesis, along with some considerations to keep in mind.

Important Site Conditions and Biological Considerations

Black rails have three main requirements for successful occupancy and breeding: 1) thick herbaceous vegetative cover, typically composed of grass-like species; 2) consistent shallow water (from moist soil to 1.5 in (4 cm) deep; and 3) variation in topography (i.e. variation and configuration of elevation within a site; (83 FR 50610, October 9, 2018)). Although these habitat requirements are important year-round for black rails,

they are especially important during the breeding season. One of the first steps for participation on this project is to become familiar with the timing of black rail breeding in your area (Table 2.1). Sites selected for this project should already have appropriate hydrology and topography but need regular management to maintain appropriate vegetative cover. See also the "Additional Biological Information" section (Appendix 3) for an expanded discussion on these three requirements.

Table 2.1. Estimated Eastern black rail (*Laterallus jamaicensis jamaicensis*) breeding season dates by state.

State	Start Date	End Date
Florida		
<ul style="list-style-type: none"> ● Everglades (area from Lake Okeechobee south) ● North and central interior, Gulf coast saltmarsh 	16 Feb 16 Apr	30 Jun 31 Aug
South Carolina	16 Apr	31 Aug
Georgia	16 Apr	31 Aug
New Jersey	16 Apr	15 Jul
North Carolina	1 May	31 Jul
Virginia	1 May	31 Jul
Maryland	1 May	31 Jul

Management Guidelines

Site Selection

To compare the effects of fire and herbicide on black rails, we are seeking sites that are, or could be, managed with fire, herbicide, or both. A site is defined as the unit of space that receives a treatment at the same time. Therefore, a site could be considered a burn unit, with different burn units constituting different sites, or a site could be the entire area that receives an herbicide treatment at a given time. Sites should be in decent condition for rails prior to joining the experiment, with, at minimum, moderate herbaceous vegetative cover ($\geq 51\%$ of total site cover) and moderate or low woody cover ($\leq 35\%$ of total site cover). For this experiment, management should maintain or promote herbaceous growth and reduce woody vegetation in whatever way is logistically feasible for the manager.

Considerations for Site Selection

- **Vegetation:** The site must be dominated ($\geq 51\%$) by herbaceous vegetation (not woody vegetation, aka shrubs) at least ~ 16 in. (40 cm) height on average to provide cover from predators. Vegetation can be wetland or upland species but should be dominated by grasses. The site should have $\leq 35\%$ woody or shrubby vegetation. The site edge should also be $\geq \sim 330$ ft. (100 m) from the nearest treeline.
- **Hydrology:** Sites should receive appropriate water levels throughout most of the breeding season most years.
- **Area:** Ideally, sites should be no smaller than 2.5 ac (1 ha).
- **Topography:** There are two scenarios where sites have appropriate microtopography for rails.
 - a relatively flat area with little overall slope can contain features such as humps, ripples, moguls, etc. that provide higher elevation areas for nesting and refugia and lower areas that remain wet when other areas may dry out.

- a sloped area can be shaped in a way that provides varying water depths, with upslope areas available for nesting and refugia. Slopes should ideally be $\leq 2^\circ$ but may be acceptable up to 10° .
- **Soil:** Any site with soil suitable for small wetland development is appropriate. Consider whether there are any materials in the soil that may inhibit plant growth or harm invertebrates such as residual herbicides, pesticides, salts, contaminants, etc.

Types of Treatment

There are three types of treatments in this experiment:

- **Prescribed Fire:** Prescribed fire is frequently used in fire-dependent systems in an attempt to mimic natural patterns of wildfires. When used properly it is generally considered to be the best tool for maintaining black rail habitat. However, there are a number of potential constraints including smoke management, availability of trained personnel and essential equipment, and, sometimes, cost.
- **Herbicide:** The use of herbicide in this case refers to the targeted use of chemicals to remove woody and/or invasive vegetation from a site, leaving the herbaceous vegetation unaffected. Using herbicides may make the timing of treatment more flexible and in some cases more cost-effective, but also comes with a number of considerations, such as the effect on non-target species, the persistence of the herbicide in the environment, the method used to deploy herbicide and reduce spray-over, etc.
- **Combined:** In some cases, managers may use both methods, often using fire as the primary tool for management and using herbicide to spot treat problem areas when either fire cannot be used as frequently as desired and/or to treat areas that fire did not successfully manage.

Conducting Treatment

Overall, we assume managers are familiar with the optimal frequency of treatments to maintain the habitat and have the appropriate training and knowledge of techniques that are best suited for their sites. In depth discussion of either is outside the scope of this document. Therefore, we only outline considerations that specifically concern black rails and their needs.

Considerations for Conducting Treatments for Black Rails

- Consider what time of year is best for treatment and attempt to balance that with the needs of breeding black rails. For instance, often prescribed fire and some herbicides are most effective when applied during the growing season. However, these activities may destroy nests, kill chicks or reduce available breeding habitat. Consider whether shifting timing of activities would still be effective and feasible. Conversely, the lost productivity of a single season may be outweighed by the long-term benefits of maintaining habitat in good condition. If you conduct activities during the breeding season, do so in a way that provides refugia for adults and chicks and minimizes possible mortality. Black rails typically run away from fire rather than flying, so it is important to leave corridors for escape and avoid fire patterns that may trap birds.
- If possible, reduce or eliminate fires during August and September. During this time of year, adult black rails cannot fly because they are regrowing their flight feathers and are at increased risk of being caught in a fire during this time.
- If conducting aerial spraying of herbicides, consider use of geo-located spraying that concentrates application on target species and reduces spray over beneficial vegetation.
- As a species listed under the federal Endangered Species Act there are specific limits related to management of black rail habitat. Please familiarize yourself with the rules in section 4d of the official listing (Federal Register 2020). See the Additional Resources section for more details.

Required Monitoring

Biological and Physical Measures

Both the treatment and control sites should be monitored for hydrology, vegetation, and black rails. We have developed specific protocols for each of these, and they can be obtained from ACJV staff. Monitoring can be conducted by those managing the site or through collaboration with others.

Measuring Time and Resources Used

Understanding the cost in time, salary, and physical resources for management and monitoring is important because it can affect the willingness of partners to participate. Once a site is enrolled in the project, we (ACJV) will send the appropriate manager or contact person a quarterly questionnaire with 5-7 questions relating to the amount of personnel time and salary and out-of-pocket expenses they and their staff invested in the project on management and monitoring activities. The questionnaire is designed to be simple and short, taking hopefully no more than 5-10 minutes each time. The form will also provide the opportunity to report on any major natural disasters or equipment failures that drastically alter the wetland, such as major unpreventable flooding, extensive dry-down, wildfire, etc., either temporarily or permanently.

Additional Resources

Financial support for monitoring and management is important and ACJV staff are available to help to obtain those resources as needed. Please reach out to their staff if you need this type of assistance.

Chapter 3: Black Rail Monitoring Protocol

Overview

This protocol is designed to detect changes to black rail occupancy due to management actions taken as part of the Atlantic Coast Joint Venture (ACJV) Adaptive Resources Management (ARM) project. The primary goal of the ARM project is to understand how management actions can increase black rail occupancy. It is critical that any partners participating in the ARM project monitor for black rails at their sites. The following sections on human and black rail safety are paraphrased from NOAA Firebird Project Breeding Rail Monitoring SOP (2022).

Human Safety – Field personnel should not work during hazardous weather conditions which can include extreme heat or cold, thunderstorms, etc. Field crews using boats should wear life jackets and adhere to their state and employer’s safety standards, and we recommend filing a float plan with a responsible contact on shore. A first aid kit should be kept in the vehicle/boat. We also recommend understanding other dangers in the field, such as the presence of venomous snakes, alligators, etc. and taking necessary protections to prevent bites and other injuries.

Bird Safety - Care should be taken while conducting call-response surveys and when leaving a point to ensure that birds which may have approached the surveyor are not stepped upon.

Protocol

All ARM sites should be surveyed using the national Eastern Black Rail Call-Response Survey Protocol (hereafter “National Protocol”; [protocol website](#); Hand et al. 2023) and should follow the breeding season timeline set out in the National Protocol (Table 3.1).

Table 3.1. Estimated dates for the first three months of the Eastern black rail (*Laterallus jamaicensis jamaicensis*) breeding season dates by state, in order of start date. Call-response and autonomous recording unit surveys should be conducted during this period.

State	Start Date	End Date
Florida		
• Everglades (area from Lake Okeechobee south)	16 Feb	15 May
• North and central interior, Gulf coast saltmarsh	16 Apr	15 Jul
South Carolina	16 Apr	15 Jul
Georgia	16 Apr	15 Jul
New Jersey	16 Apr	15 Jul
North Carolina	1 May	31 Jul
Virginia	1 May	31 Jul
Maryland	1 May	31 Jul

Call-response data can be supplemented by, and if necessary replaced by, data collection with autonomous recording units (ARUs). Be aware that though ARUs may reduce reliance on field personnel, they require substantial effort processing data post-breeding season, even when automated recognizers are used. Projects considering using ARUs should consult researchers with prior ARU experience to understand the demands and should allocate appropriate funds and human resources accordingly.

ARUs should be deployed in a configuration similar to call-response points, following the guidance from the National Protocol. Because ARU data collection is passive (i.e., not generally paired with call playback), ARUs should be programmed to record during periods when black rails are most likely to vocalize. Black rails vocalize at different times of day based, on latitude and we recommend sampling during the time of day appropriate for your project's latitude. Nocturnal survey periods are typically most productive in the mid-Atlantic states south to North Carolina, whereas crepuscular survey periods are preferred from South Carolina south to the Gulf Coast. However, black rails may also call in non-peak periods regardless of latitude so we also recommend recording *at minimum* three 30-minute recordings per day, one during the period from sunrise until 2 hours past sunrise, one in the period 1.5 hours prior to sunset to 0.5 hours after sunset, and one during the night-time period (12-3 am), with additional recordings taken in peak calling period for your area. We recommend recording daily throughout the early breeding season for your state (Table 3.1).

Reporting Data

For call-response data, the National Protocol also includes a data entry template that should be used for data entry and reporting to the ACJV. Please send collected data entered into this template by attaching the populated template to an email addressed to maureen_correll@fws.gov. Please follow the naming convention guidance in the ARM Field Study Design document to ensure that survey point names are distinct across survey sites. Point names should remain the same throughout the duration of the ARM project. If the collectors of survey data wish to hold back specific spatial information linked to black rail detections, the columns "Lat" and "Lon" on the "Points" tab containing latitude and longitude for survey point locations should be removed from the template before sending data to the ACJV.

Post-season Processing

ARU data reporting standards are still in development.

Literature Cited

Hand, C., A. Schwarzer, M. Correll, A. Godar, H. Levy, L. Rossi, M. Stantial, and M. Wolf. 2023. Eastern Black Rail Call-Response Survey Protocol. Eastern Black Rail Protocol Team. Version 1.0.
<https://www.fws.gov/media/eastern-black-rail-call-response-survey-protocol-range-wide-monitoring>

NOAA Firebird Project. 2022. Breeding Rail Monitoring SOP. Version 4.0.
<https://noaafirebird.home.blog/project-details/field-sops/>

Chapter 4: Hydrology Sampling Protocol

Mikayla Thistle, Christy Hand, and Amy Schwarzer

Overview

This protocol is designed to assess suitability of hydrologic conditions for black rail occupancy by measuring soil and surface water depths at project sites throughout the black rail breeding season as part of the Atlantic Coast Joint Venture (ACJV) Adaptive Resources Management project (ARM). Black rails require shallow but consistent wet areas within their home range throughout the breeding season, typically from wet soil to 3 cm deep (Watts 2022). Although adults can tolerate depths up to 5 cm, it is critical that chicks have moist/wet areas to forage that are ≤ 2 cm (Hand et al. 2021).

The ACJV ARM project consists of sub-projects regarding the effects of management occupancy - (1) Irrigation and (2) Fire vs. Herbicide - and hydrology plays a different role in each of these. However, despite project differences, hydrology is an important variable when assessing why a site may or may not be occupied and how management affects black rails.

Safety considerations

The following sections on human and black rail nest safety are paraphrased from NOAA Firebird Project Vegetation Sampling SOP (2022).

Human Safety – Field personnel should not work during hazardous weather conditions which can include extreme heat or cold, thunderstorms, etc. Field crews using boats should wear life jackets and adhere to their state and employer’s safety standards, and we recommend filing a float plan with a responsible contact on shore. A first aid kit should be kept in the vehicle/boat. We also recommend understanding other dangers in the field, such as the presence of venomous snakes, alligators, etc. and taking necessary precautions to prevent bites and other injuries.

Black Rail Nest Safety – Typically, hydrology monitoring equipment should be deployed before or at the very beginning of the breeding season for your area (see Table 4.1 for approximate breeding season dates for the Atlantic Coast states). However, crews will need to check equipment, change batteries and retrieve and replace memory cards on a monthly basis. Therefore, crews should be able to identify black rails by ear. Call-type examples and surveyor training files are available here: [Resources - Eastern Black Rail Call-Response Survey Protocol](#).

Eastern black rails create a defensive diversion call (“*tch-tch-tch*” in Conway 2011, “*ink-ink-ink*” according to Sibley guides) when people approach within several meters of an active nest or brood of chicks. If field personnel hear this call, they should assume they are near an active black rail nest or brood, should record their current GPS coordinates with estimated distance and bearing to the calling, and leave the area immediately using the same route they used to approach the coordinates. Field personnel should not attempt sampling in or traversing through that location until at least 3 weeks after the encounter.

Field personnel should observe a 50-m radius buffer around the GPS coordinates, refraining from all activities within the buffer until 3 weeks have passed. Field personnel should also be aware of other black rail calls such as *kickee-doo*, *churt* and *growl*, and avoid approaching them. Black rails are more

commonly heard than seen. Therefore, when traveling through vegetated habitats, field personnel should walk slowly and carefully, listen for vocalizations, and carefully move away from broods if observed. For hydrology sampling, consider establishing one set path to reduce impacts on the habitat.

When to Sample

Hydrology sampling should occur throughout the breeding season, with equipment deployed at or near the beginning of the breeding season and retrieved after it is likely that there are no small chicks present.

Table 4.1. Estimated Eastern black rail (*Laterallus jamaicensis jamaicensis*) breeding season dates by state.

State	Start Date	End Date
Florida		
<ul style="list-style-type: none"> ● Everglades (area from Lake Okeechobee south) ● North and central interior, Gulf coast saltmarsh 	16 Feb 16 Apr	30 Jun 31 Aug
South Carolina	16 Apr	31 Aug
Georgia	16 Apr	31 Aug
New Jersey	16 Apr	15 Jul
North Carolina	1 May	31 Jul
Virginia	1 May	31 Jul
Maryland	1 May	31 Jul

Sampling Area

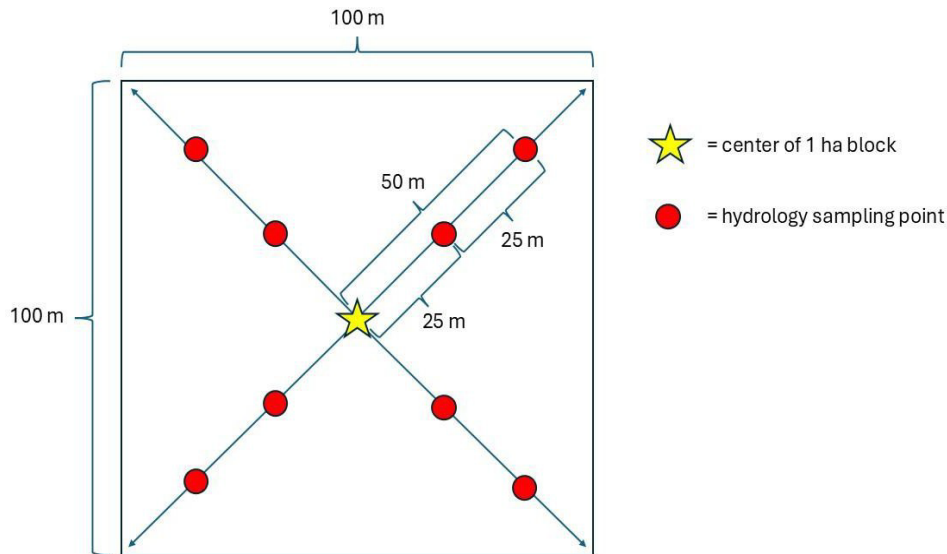
The two ARM projects operate at different scales and require different levels of detail when measuring hydrology. Fire and herbicide sites could be tens to hundreds or even thousands of hectares, whereas irrigation sites are expected to be considerably smaller given logistic constraints (approximately 1 ha).

Sites Using Fire vs. Herbicide Management Treatments

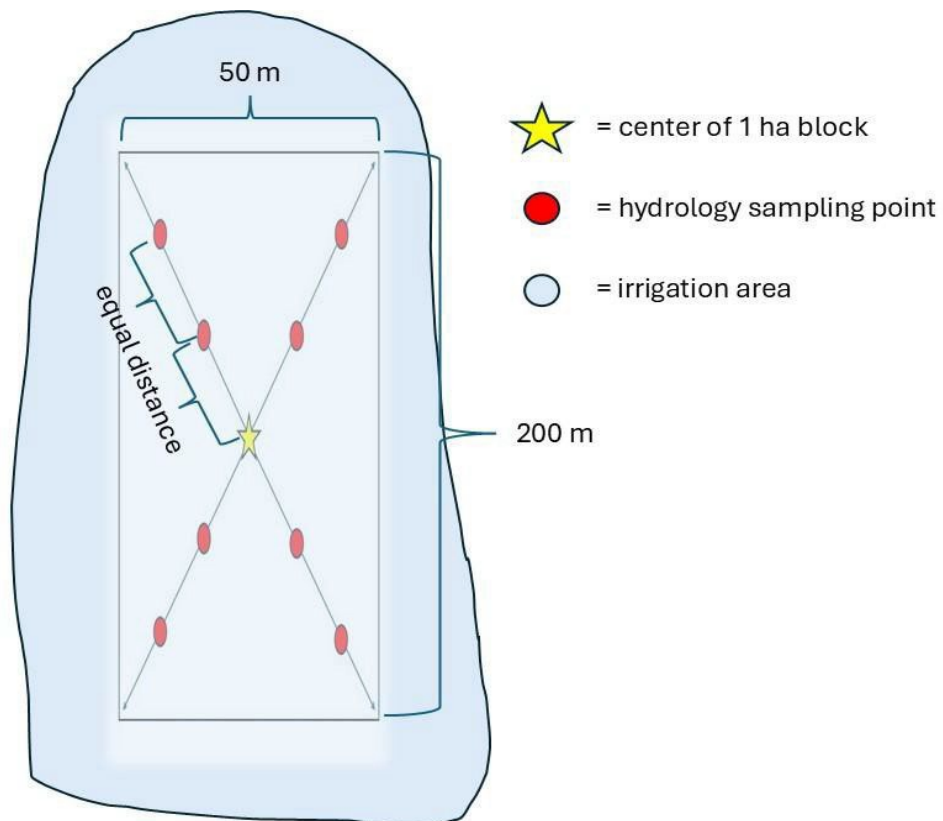
Plan to place one set of hydrology monitoring equipment - which includes a float ruler (described below), a camera, and mounting materials - near each black rail call-playback survey point. The monitoring equipment should be placed in the lowest elevation area of the potential black rail habitat within 50 m of the survey location and generally representative of the vegetated marsh included in that radius, even if the call-playback survey point is on the habitat edge or on something such as a dike or road. This placement ensures that the equipment will not be placed in an area that may be higher and therefore dry all season long. The equipment should also not be placed at the same location with the bird call-playback survey location, so as to not disturb bird surveys, but be located within 50 m of it to ensure that the area of inference for the bird survey point and the hydrology monitoring overlap. Avoid walking through hydrology monitoring area on the way to the call-playback survey points, as additional visits may artificially impact ground elevation and change relative water measurements.

Sites Using Irrigation Treatments

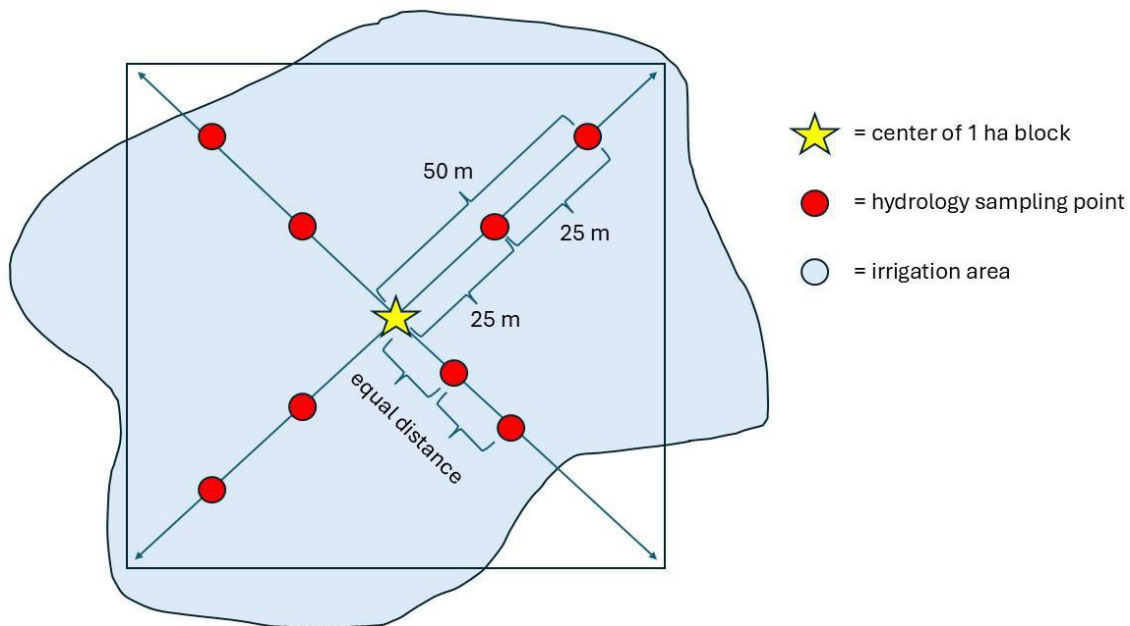
Using the GIS platform of your choice, divide potentially suitable habitat in each irrigation site into 1 ha blocks. Place eight hydrology sampling plots, two points each at 25 m and 50 m along four diagonals from the center of each 1-ha block (Figure 1a). The 1 ha block shape or the placement of the hydrology sampling points can be modified based on the shape and size of the irrigation area and suitable habitat (Figure 1b and 1c, respectively).



a)



b)



c)

Figure 1. Example designs of 1-ha block and hydrology sampling plots for irrigation projects. a) shows the basic design, b) is an example of how the 1-ha block can be modified if the irrigation is oriented in a narrow configuration, and c) is how to modify sampling plots when the habitat is irregularly shaped.

Not all irrigation sites will accommodate perfectly square 1-ha blocks, and the grid can be modified to fit with spatial arrangement of the site. However, stratified-random sampling should still be used, with 25 10x10 m plots in each quarter of the block.

Wetland Scale Monitoring

In some cases, water flow into or out of wetlands may be controlled or channelized. In these cases, it can be very useful to have data on the water level at water control structures or channels to understand hydrologic dynamics in the wetland. In these types of cases, it is recommended that a camera and staff gauge be placed in these locations.

Basic Field Equipment

- First aid kit
- Sunglasses or safety goggles to prevent eye injury from *Juncus sp.*
- Cell phone or tablet with Avenza maps/Field maps loaded with hydrology sampling points OR GPS unit with appropriate maps loaded and batteries
- Adequate number of float rulers for your site (see below for construction instructions) and same number of suspension clamps
- Adequate number of 3 ft. light duty T-post
- Adequate number of cellular trail cameras and mounting equipment (4 ft, T-post)
- SD Cards

- AA rechargeable batteries
- Post hole diggers and/or trowel
- Assorted zip ties (primarily large)
- Scissors
- Twine

Float Ruler Construction

Below you will find instructions for constructing a float ruler designed by South Carolina Department of Natural Resources staff (Thistle 2024). Some projects may need to modify this design based on cost, logistics, field conditions, and other concerns. The main priority is to retain accuracy at the 1-cm level and to be able to assess water depth below the marsh surface up to 10 cm.

Equipment Needed:

PVC Cutter
 Drill
 Drill bits (approx. 3/8" and 3/16")
 Sandpaper
 Scissors
 Knife

Supplies Needed:

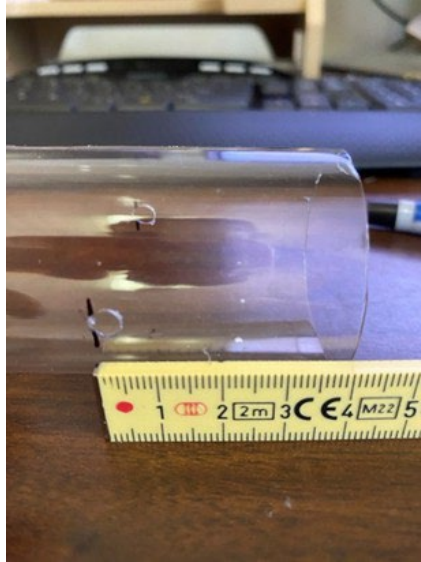
For one Float Ruler

1-24 in. clear plastic PVC tube (1.5 in diameter)
 2-1.5 in. diameter PVC caps
 1- 0-35 cm ruler sticker (Custom made through Sticker Mule)
 1- -22-13 cm ruler sticker (Custom made through StickerMule)
 1-12 in. piece of 1.4-in foam rod¹
 1-12x1-1/2 Sheet metal screw (Stainless Steel)
 1-1/4x1 Fender washer
 (Stainless Steel) Fishing line
 1-Sheer knee-high stocking
 5-12 in. zip ties

NOTE: Accurate measurements during construction are very important! Although we are only measuring to 1-cm accuracy, errors in construction will lead to inaccurate data. Be as accurate as possible.

¹ Foam rods have been used in all previous designs. However, they gather algae quickly, are difficult to clean, and may be destroyed by invertebrates. Hard plastic floats may be substituted if they work as needed.

1. Mark the PVC tube 4 cm up from both ends. Roll the tube over 180 degrees and mark 4 cm up on the other side. Drill a 3/16 in. hole on each mark so that the top of the hole is just on the short side of the tube (see photo below). This is the hole the zip ties will eventually go through. It is important that the top edge of the zip tie hits the mark.



2. Mark 22 cm up from the 4 cm mark. Drill ten 3/8 in. holes between these two marks, as pictured. Place one of the PVC caps on the tube (picture shows a vinyl cap but the process is the same) and drill a 3/8 in. hole through it. Then remove the cap.



3. Sand the holes from the inside of the tube so that there are no burrs that the float can catch on. I used a small sanding band attached to a long rod.



4. Place the ruler stickers on the PVC tube above the large holes, as pictured. Place the -22 to 13 cm ruler on the right and the 0 to 35 cm sticker on the left. The -20 cm mark on the -22 to 13 cm ruler sticker and the 0 cm mark on the 0 to 35 cm ruler sticker should line up with the 22 cm mark on the tube. *BE SURE NOT TO STRETCH THE STICKERS!* Keep about 1 cm spacing between the stickers and make sure that when you look at the tube straight on, all numbers are visible. The tops of the stickers may need to be trimmed slightly.



5. Place two zip ties through the small bottom holes, as pictured. Keep the zip ties fairly loose so that the tube does not warp. Trim the ends. The float will sit on these zip ties.



6. Paint the 22 cm piece of foam rod white. When it dries, paint the top surface of one end black, as pictured. When all the paint dries, screw the washer and screw into the black end. Tie a piece of fishing line on the screw so that the float can be pulled out of the float ruler if needed when it has been installed. The washer and screw help slightly weigh down the float so that it does not get stuck in the tube.



- Place the drilled vinyl cap on the bottom of the ruler. Starting at the cap, pull the stocking taut over the bottom of the tube. Place the suspension clamp over the stocking so that the tabs are at the 0 and -20 cm marks and the band faces the side with the drilled holes. Zip tie the tabs together so that it is secured, but not enough to warp the tube. Fold the stocking back over the bottom of the well and tie the rest in a knot at the bottom of the well at the PVC cap. Trim the excess stocking off of the knot. Attach another zip tie under the band.



- Place the float in the tube so that the screw is facing up and the fishing line comes out of the tube. The top of the float should sit on the 0 and -20 cm line. Loosely attach one zip tie through the top 3/16 in. holes, as pictured. Place the second undrilled vinyl cap on top so that it does not close the 3/16 in. holes and so that the fishing line sticks out of the tube.



9. Test that the float can move freely and that it reads accurately. You can use a bucket filled with water for testing. If so, it is ready to deploy!



Float Ruler Deployment

1. For fire projects, find the lowest elevation point within the black rail habitat that is within the 50-m radius of the bird survey point. For irrigation projects, assess the 10x10 m plot visually. The float ruler should be placed in what appears to be the lowest elevation section of the plot (i.e., the most likely to be wet). Record the location with a GPS unit. When naming float ruler locations, make sure that the float ruler data can be connected to black rail survey and vegetation survey data and, in the cases of irrigation plots, the hectare block and individual plot.
2. Try to disturb the microtopography as little as possible during installation. Try to put excess soil from digging well holes out of the data collection area.
3. Dig a small hole to fit the equipment being installed with a post hole digger or a trowel. The hole must be deep enough so that the suspension clamp on the float ruler sits at ground level.
4. Attach the float ruler to a 3 ft. light duty T-post and place the post into the hole.
5. Check that the suspension clamps are the appropriate distance from the zip tie at the bottom of the well/float ruler, i.e. float ruler: 12.5 cm (ground level is marked on the ruler). Place the float ruler in the hole so that it sits with the suspension clamp at ground level and is flush with the T-post. Make sure that the front of the float ruler is facing in the direction of the camera. Secure the float ruler to the T-post with zip ties. If the water level is above ground level, measure the water prior to digging. Once the float ruler is installed check to confirm that this

measurement and the reading on the float ruler are the same. This helps confirm that the float ruler is operating correctly.

6. Fill in the hole around the float ruler and T-post with the removed soil until the soil is compacted and flush with the surrounding ground. It may take some time for the float ruler to equilibrate after installation (usually within an hour). This may differ with soil type and permeability, so do not worry if it does not immediately read correctly.

Camera Deployment

1. Place the camera on a 3 ft. T-post. Keep the camera high enough off the ground to prevent flooding the camera if water levels rise rapidly.
2. Aim the camera at the float ruler so that the ruler and float can easily be seen. The aim should be checked using the appropriate application or other software for your camera.
3. Sync the camera time to local time as per camera specifications. Set the camera to take pictures at 0:00, 6:00, 12:00 and 18:00 every day. In tidal environments, we recommend setting the camera to capture more regular images (up to once an hour) to help capture high water events that may disrupt rail occupancy and breeding. Consult ACJV staff if you have additional questions regarding your site.
4. Tie back any vegetation that may obstruct the view of the float ruler. Vegetation can also be cut if necessary for excessively windy sites, but destruction of vegetation should be kept to a minimum.

Picture below shows an example of the final set up. The float ruler shown is an older model and is paired with a salinity meter, but the overall setup corresponds to the current protocol.



Maintenance

Batteries and SD cards should be changed and data downloaded once a month. Although battery life and SD card capacity may allow for the maintenance period to be extended, we recommend where possible to stick to a monthly schedule. This ensures that malfunctioning equipment or other problems will be noticed sooner. If the cameras used can be accessed remotely (e.g., cellular-enabled cameras), the monthly schedule can be extended with fewer concerns as long as the files are checked regularly to ensure proper functioning.

Be aware that after changing batteries, the field crew should ensure that the internal clock and selected photo times are still correct on the camera. Depending on the model of camera used, this may be checked on the camera itself or through an application on a phone. Floats and PVC should be routinely cleaned as needed. A dish brush can be used to scrub the front so the ruler can be read, a bottle brush can clean the inside, and the float can be pulled out and wiped off. This ensures that the float ruler continues to operate smoothly and avoids buildup of algae on the float which can distort measurements by weighing down the float.

Equipment Removal

At the end of the breeding season, all materials including float rulers, cameras, T-posts, and miscellaneous items such as zip ties and flagging should be removed from the field. If the site is part of a multi-year project and you wish to deploy float rulers in the exact location from year to year, you can mark the float ruler location with a low-profile, corrosion- and weather-resistant marker (fiberglass driveway markers are one alternative that have already been used successfully). The marker should be no higher than the surrounding vegetation, so as to avoid becoming a perch for avian predators, and it is recommended that it be at least a few inches lower. This marker should be removed at the end of the project at that site.

Materials removed from the field should be thoroughly cleaned before storage. We recommend, when possible, to repair units and replace corroded or damaged parts immediately after removal.

Post-season Processing

We plan to automate the process of reading the float ruler measurements to avoid the time-consuming task of manually processing the data.

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Chapter 5: Vegetation Sampling Protocol

Overview

This protocol is designed to measure vegetation in order to assess changes in cover, structure and community due to management actions taken as part of the Atlantic Coast Joint Venture (ACJV) Adaptive Resources Management project (ARM). Black rails require thick cover over most of their territory along with structure that allows them to move underneath the vegetation. Generally, they prefer clumping grass species, but are not restricted to specific species of vegetation, inhabiting a variety of shallow freshwater and saltwater wetlands and occasionally wet meadows and prairies. Studies have shown amount of cover, structure and stem density to be important factors affecting black rail occupancy and home site selection during breeding (e.g., Flores and Eddleman 1995, Spautz et al. 2006, Tolliver et al. 2018).

The North American Secretive Marshbird Protocol (Conway 2011) and the Saltmarsh Habitat and Avian Research Program (tidalmarshbirds.org) both recommend the collection of habitat data along with point count data. Although these two protocols differ somewhat, one main commonality is the collection of percent cover data within a 50-m radius of the point. To that end, we will also collect these data as part of the ARM project. Percent cover can be hard to estimate in such a large area, and accuracy can be improved when observers divide the circle into quarters and visually estimate the percent cover in each quarter. In addition to overall cover, observers will also be measuring density and structure at points within the 50-m radius circle.

The following sections on human and black rail nest safety are paraphrased from NOAA Firebird Project Vegetation Sampling SOP (2022).

Human Safety – Field personnel should not work during hazardous weather conditions which can include extreme heat or cold, thunderstorms, etc. Field crews using boats should wear life jackets and adhere to their state and employer’s safety standards, and we recommend filing a float plan with a responsible contact on shore. A first aid kit should be kept in the vehicle/boat. We also recommend understanding other dangers in the field, such as the presence of venomous snakes, alligators, etc. and taking necessary precautions to prevent bites and other injuries.

Black Rail Nest Safety - Crews should be trained to identify black rail calls. Call type examples can be found at: Resources – Eastern Black Rail Call-Response Survey Protocol (https://drive.google.com/drive/folders/1_NgvU_VGrXWeP-PW-ItvpsM102gJxJFj?usp=drive_link). Eastern black rails create a defensive diversion call (“*tch-tch-tch*” in Conway 2011, “*ink-ink-ink*” according to Sibley guides) when people approach within several meters of an active nest or brood of chicks. If field personnel hear this call, they should assume they are near an active black rail nest or brood, should record their current GPS coordinates with estimated distance and bearing to the calling, and leave the area immediately using the same route they used to approach the coordinates. Field personnel should not attempt sampling again until at least 3 weeks after the encounter. Field personnel should observe a 50-m radius buffer around the GPS coordinates, refraining from all activities within the sampling area until 3 weeks have passed. Field personnel should also be aware of other black rail calls such as *kickee-doo*, *churt* and *growl*, and avoid approaching them. Black rails are more commonly

heard than seen. Therefore, when traveling through vegetated habitats, field personnel should walk slowly and carefully, listen for vocalizations, and carefully move away from broods if observed.

When to Sample

Vegetation sampling can occur from the late growing season and into the dormant season, generally at the end of or after the black rail breeding season. However, sampling should take place before the dormant vegetation dies, collapses, or otherwise loses its growing season structure.

Sampling Area

Vegetation should be sampled at each call playback survey point and ARU point within the study area, with the center of the circle centered on the survey/ARU point. Overall cover will be estimated within a 50-m radius from the center. Robel pole vegetation obstruction will be taken at six subsampling locations within the 50-m radius. Select the sampling points by generating a list of random bearings (0-359 degrees) and distances (1-49 meters).

Equipment

- First aid kit
- Sunglasses or safety goggles to prevent eye injury from *Juncus sp.*
- Cell phone or tablet with Avenza maps/Field maps loaded with call survey points OR GPS unit with appropriate maps loaded and batteries
- Clipboard sheet holders and field datasheets on waterproof paper OR electronic device with an application equipped to record data
- Writing utensil- #2 lead pencil (including pencil sharpener or extra leads) or waterproof pen
- Light gloves (optional, some vegetation can be sharp and/or pokey)
- Sighting (mirrored) compass
- Robel Pole

A two-meter tall, PVC pipe with an inch-wide outside diameter of 1", with 10-cm increments marked along its length in alternating black and white strips. Note: 3/4" schedule 40 PVC tubing has a 1" outside diameter. A rope, cord, or coated wire cable of 4 m in length should also be attached halfway up the Robel pole. The material of the cord should be low stretch and should be remeasured regularly to ensure it is still 4 m in length. This should be accompanied by a meter stick, to aid the observer in being far enough away, and at the right height for observation. Also include rebar if doing the work as a single individual to stand pole upright without a second person.

Data Collection

Before beginning vegetation sampling, record the point name, date (month/day/year), and the name of the observers on the data sheet.

Percent Cover

While standing at the center of the plot (typically the call playback or ARU survey point), visually estimate the % coverage of the different plant species with a minimum of 5% coverage within the plot (the area within the 50-m radius circle around the point).

- Dead standing vegetation should be recorded as its own separate category but does not include vegetation that is on the ground and decomposing.
- Include water if the plot has $\geq 5\%$ open water
- Include wrack if $\geq 5\%$
- Likewise, record bare ground such as salt pannes, mud flats, etc. if it constitutes $\geq 5\%$ of the plot.

If a survey point is on a road, dike or upland edge, where the immediate habitat is not suitable, that is okay. Include all types of cover in the percent cover data, as this still represents the habitat within 50-m of an observer from the survey point.

In some cases, species can become truly intermixed and create structural forms different than the individual species when separate. These mixes should be noted as their own category. For instance, an area may consist of a patch of *Distichlis spicata*, a patch of *Borrchia frutescens*, and an intermixed patch of both. In this case, you would record three percentages - one for the *Distichlis*, one for the *Borrchia* and one for the mixture - as opposed to only two percentages, one for each species. Mixtures should only be recorded if they represent a large patch and should not be recorded when edges of distinct patches overlap in minor ways. A list of common intermixes as well as instructions on how to add additional intermixes can be found on the data entry form that accompanies this protocol.

The circle should be divided into quarters for more accurate sampling. Using the compass, begin at compass bearing 0°. Quarter 1 is between 0-90 degrees, quarter 2 between 90-180 degrees, etc. Alternatively, if you are taking the measure from a road or dike, you can orient the quarters parallel and perpendicular to the road for ease. Record percentages within quarters and the percentages within each quarter should add up to 100%.

If your sightline is blocked by trees and shrubs, feel free to walk around within the 50-m radius area to get a better sense of coverage.

Optional measure: Some projects may wish to have a better understanding of how management affects woody species. In this case, observers can count the number of trees and the number of shrubs present within the sampling radius.

Robel Pole for Visual Obstruction

For this measure, select the six sampling points by generating a list of random bearings (0-359 degrees) and distances (1-49 meters). Sample only within the marsh area. If a point falls outside of the marsh (i.e., in open water, berm, inappropriate upland habitat, etc.), choose another randomized bearing and distance.

Place the Robel pole at each of these points. For someone working solo, place the Robel pole over a piece of rebar stuck in the ground that is visible when you step away. First, record the dominant vegetation type touching the Robel pole. Then, readings will be taken at a distance of 4 m 90° to the east of the Robel pole, such that the surveyor's eyes are at a height of 1 m above the ground. First, starting from the ground, scan up and record the first stripe that is at least partially visible (e.g., if the first three intervals are completely obscured and a portion of the fourth interval is partially visible, record 40 cm; if the base of the pole is visible, record 10 cm for the 0-10 cm stripe). Repeat the measure from top down. Starting at the top of the pole, scan down and record the last interval that *is not*

completely obscured (e.g. if the 40-cm interval is completely obscured, and at least part of the fifth interval is partially visible, record 50 cm).

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Comments:

Appendix 1: Bayesian Decision Model for Supplemental Irrigation

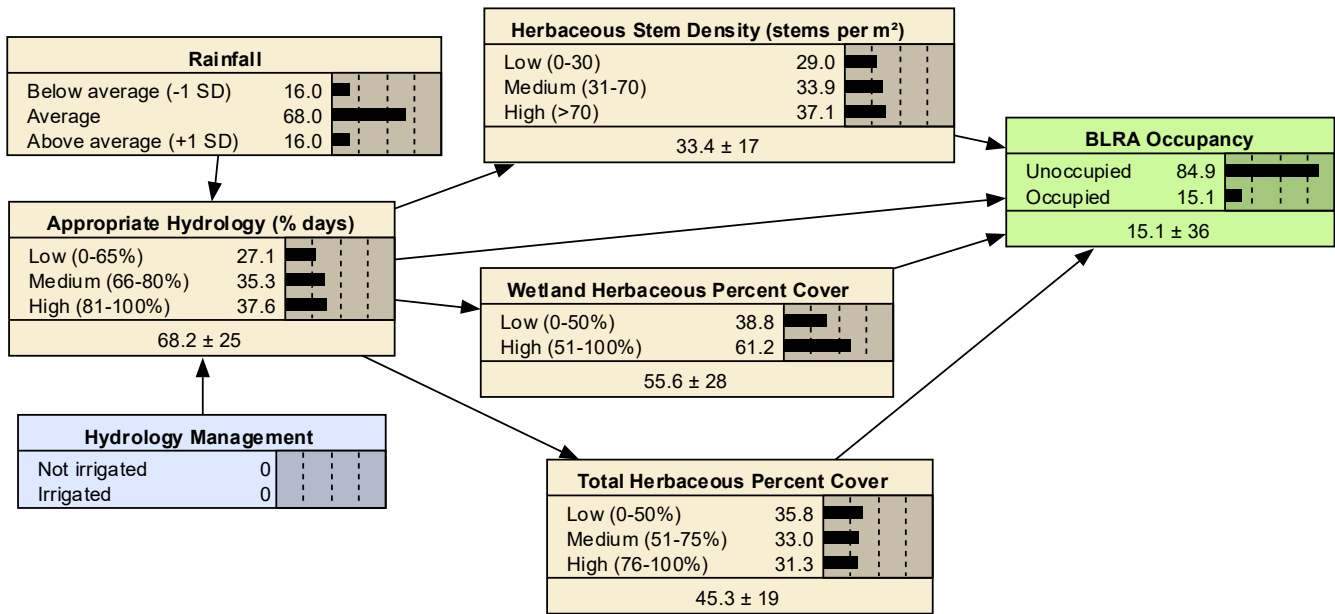


Figure A1. Bayesian Decision Network to evaluate the effects of irrigation management on Eastern black rail occupancy. The blue decision node (“Hydrology Management”) represents the choice to irrigate or not irrigate. Rainfall (dry, average, wet) influences the proportion of days with appropriate hydrology (percent of the breeding season with ≥ 0.5 ha of moist soil to 4 cm depth). Hydrology and rainfall affect vegetation structure, including total herbaceous stem density, total herbaceous percent cover (percent of the field in herbaceous vegetation), and wetland herbaceous percent cover (percent of herbaceous cover comprised of wetland species). The values at the bottom of each node represent the expected value and standard deviation. The vegetation and hydrology nodes collectively determine the probability of black rail occupancy (occupied/unoccupied), which is the green fundamental objective node of the model.

Appendix 2: Bayesian Decision Model for Fire and Herbicide

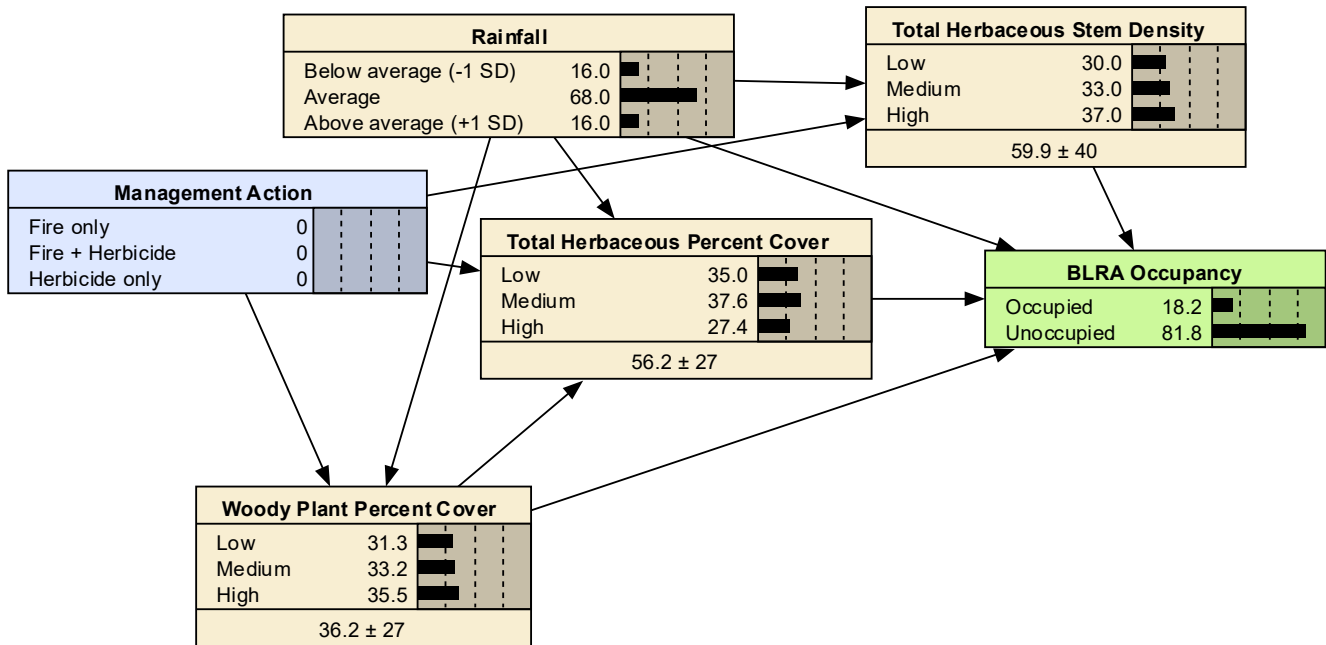


Figure A2. Bayesian Decision Network (Fire vs. Herbicide Model) developed to evaluate the effects of prescribed fire and herbicide treatments on Eastern black rail occupancy. The blue decision node represents the choice of management action (prescribed fire, herbicide, or both). Rainfall (dry, average, or wet year) influences vegetation responses. Management and rainfall jointly affect woody plant percent cover, total herbaceous percent cover, and total herbaceous stem density within the treatment field. The values at the bottom of each node represent the expected value and standard deviation. These vegetation structure nodes collectively determine the probability of black rail occupancy (occupied/unoccupied), which is the green fundamental objective node of the model.

Appendix 3: Additional Biological Information

When managing for a species it is important to understand some of the basic biology of a species outside of what is being managed. The following section briefly discusses some key points about black rail biology and habitat needs.

Basic Biology

The Eastern black rail (*Laterallus jamaicensis jamaicensis*) is the smallest and rarest of the North American rails. Due to an extensive decline in both range and population, the subspecies was federally listed on the Endangered Species List as Threatened in 2020 (85 FR 63764, October 8, 2020). Though capable of living in salt, brackish and freshwater marshes, the species is rare due to its specific habitat needs within these wetland types (more on habitat needs below). Black rails breed primarily during the spring and summer, though initiation of nesting and length of breeding season varies from north to south (Table 4.1). Black rails build nest platforms only a few centimeters off the ground and egg-laying and incubation lasts approximately 26 days (Hand et al. 2021). Chicks leave the nest shortly after hatching and take at least 42 days to become capable of flight (Hand et al. 2021). Although the habitat requirements listed below are important year-round for black rails, they are especially important during the breeding season.

Habitat Needs

Vegetative Cover

Black rails prefer to stay hidden, often choosing to run rather than fly to evade predators and disturbances. Thus, they tend to occupy sites with dense vegetative cover, particularly clumping grasses that provide overhead cover and leave the ground level relatively open for freedom of movement. This can include shallow-water species such as salt meadow hay (*Sporobolus pumilus* formerly *Spartina patens*), gulf cordgrass (*S. spartinae*), bunch cordgrass (*S. bakeri*), little bluestem (*Schizachyrium scoparium*), marsh fimbry (*Fimbristylis castanea*), black needlerush (*Juncus roemerianus*) and sawgrass (*Cladium jamaicensis*) (Watts 2022), as well as upland vegetation that mimics this structure. Black rails are not often associated with deeper-water plant species, unless those species also tolerate drier conditions as well. Generally, the more cover the better, however it is sometimes possible for some plant species to become too thick (notably *S. patens*), particularly when the vegetation collapses and blocks movement at the ground level, through lack of management.

Water

Appropriate water depth is critical for black rails, along with soil moisture. If an area is too dry, black rails are unable to forage, however if it is too deep black rails are unable to use the area (their legs are just too short!). Adult black rails prefer very shallowly flooded marshes, typically using areas with saturated soil to about 2 inches (0–5 cm) of standing water. They forage and move most easily where water forms only a thin sheet over the substrate, and they generally avoid areas with water deeper than about 4 inches (10 cm), where movement becomes difficult and predation risk increases. After leaving the nest, black rail chicks require even shallower conditions. They do best on damp soil or in water less than about 3/4 inch (2 cm) deep, and they avoid areas deeper than roughly 2 inches (5 cm; Flores and Eddleman 1995, Hand et al. 2021).

Micro-topography

Black rails rely on slight variations in elevation within their breeding territories (i.e., micro-topography) for protection against flooding during nesting. They need low, consistently wet areas for foraging. Higher areas (often only centimeters higher than the surrounding area) are appropriate for nesting and for temporary refuge during heavy rains. Entirely flat ground or uniform slopes are not appropriate for

black rails (Haverland et al. 2021, Richmond et al. 2008, Watts 2022).

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Appendix 4: Acknowledgments

We are grateful to the dozens of land managers, biologists, modelers, and species experts who participated in adaptive management workshops and informed the protocols and guidance included here. We thank A. Lawson and A. Godar for facilitating workshops, conceiving the models, and implementing the Bayesian Decision Models (Appendices 1 and 2). Christy Hand and Mikayla Thistle of the South Carolina Department of Natural Resources conducted research and development for irrigation and hydrology monitoring protocols for Eastern black rail. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.