Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2019 Updates to California Black Rail (*Laterallus jamaicensis coturniculus* Ridgway) (BLRA) Basic Conceptual Ecological Model for the Lower Colorado River

Photo courtesy of the Bureau of Reclamation

June 2020

Work conducted under LCR MSCP Work Task G6

Lower Colorado River Multi-Species Conservation Program
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Multi-Species Conservation Program

2019 Updates to
California Black Rail
(*Laterallus jamaicensis coturniculus* Ridgway) (BLRA)
Basic Conceptual Ecological Model for the Lower Colorado River

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ACRONYMS AND ABBREVIATIONS

BLRA	California black rail (*Laterallus jamaicensis coturniculus* Ridgway)
CAP	critical biological activity or process
CEM	conceptual ecological model
CF	controlling factor
cm	centimeter(s)
ha	hectare(s)
HE	habitat element
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LSO	life-stage outcome
mm	millimeter(s)
Reclamation	Bureau of Reclamation

Symbols

>	greater than
<	less than
≤	less than or equal to
%	percent

Definitions

For the purposes of this document, vegetation layers are defined as follows:

Canopy – The canopy is the uppermost strata within a plant community. The canopy is exposed to the sun and captures the majority of its radiant energy.

Understory – The understory comprises plant life growing beneath the canopy without penetrating it to any extent. The understory exists in the shade of the canopy and usually has lower light and higher humidity levels. The understory includes subcanopy trees and the shrub and herbaceous layers.

Shrub layer – The shrub layer is comprised of woody plants between 0.5 and 2.0 meters in height.

Herbaceous layer – The herbaceous layer is most commonly defined as the forest stratum composed of all vascular species that are 0.5 meter or less in height.

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Foreword

This report provides an update to the original conceptual ecological model (CEM) prepared for the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) for the California black rail (*Laterallus jamaicensis coturniculus* Ridgway (BLRA) (Marty and Unnasch 2015). This update incorporates information reported in publications and presentations at professional meetings since the completion of the original BLRA conceptual ecological model and also incorporates information from the professional experiences of LCR MSCP staff and other experts. An updated version of the CEM workbook incorporates the new information. This report constitutes an appendix to the original CEM. The full CEM report, including its life-stage diagrams, has not been updated.

The structure of this update follows the structure of the original CEM report. Specifically, it presents and documents updates to chapters 1–6. It does not include updates to the original Executive Summary or chapters 7–8 because they were not updated.

The updates reported herein change the BLRA conceptual ecological model in several ways. The terminology used has been updated and standardized to be consistent across species as much as possible. One critical biological activity and process was split into separate activities and processes to better reflect its effects on different life stages and for consistency with other CEMs. Several changes were made to habitat elements: (1) deletion of one element by merging into another habitat element for consistency and simplification and (2) separation of one former combined habitat element into two separate elements each to better reflect different components of habitat. One controlling factor was added for consistency with species with similar habitat management. These major changes have created numerous edits and adjustments throughout the CEM text and workbook.

This report also provides a list of all literature cited in the updates to chapters 1–6 and provides a list of all changes made to the name of the CEM components in order to standardize terminology across all CEMs.

This update both explicitly and implicitly identifies possible new research and monitoring questions concerning gaps in knowledge that may bear on adaptive management of BLRA. These questions may or may not reflect the current or future goals of the LCR MCSP decision making and are in no way meant as a call for the Bureau of Reclamation to undertake research to fill the identified knowledge gaps.

Updates to Chapter 1 – Introduction

The information in paragraph three in this chapter is updated as follows:

The most widely used sources of information for the California black rail (*Laterallus jamaicensis coturniculus* Ridgway (BLRA) conceptual ecological model are Bureau of Reclamation (Reclamation) (2008), Butler et al. (2014), Conway and Sulzman (2007), DUDEK (2014), Eddleman et al. (2020), Evens et al. (1991), Flores (1991), Nadeau et al. (2011), Repking and Ohmart (1977), and Taylor and van Perlo (1998). Many of these publications summarize and cite large bodies of earlier studies. Where appropriate and accessible, those earlier studies are directly cited. The conceptual ecological model (CEM) also integrates numerous additional sources, particularly reports and articles completed since the aforementioned publications; information on current research projects; and the expert knowledge of Lower Colorado River Multi-Species Conservation Program (LCR MSCP) avian biologists. The purpose of the CEM is not to provide an updated literature review but to integrate the available information and knowledge into a CEM so it can be used for adaptive management.

UPDATE TO CALIFORNIA BLACK RAIL REPRODUCTIVE ECOLOGY

Pair formation begins the breeding cycle for BLRA typically in late February (Eddleman et al. 2020). Assuming calls indicate the dates of pair formation, breeding along the lower Colorado River (LCR) may span from February into July (Flores 1991). Nests are constructed on sites with both dead vegetation and new growth and placed over moist soil of very shallow water usually on slightly higher ground within marsh habitat (Eddleman et al. 2020). Flores and Eddleman (1993) studied BLRA nesting activity along the LCR and recorded an average of 4.8 eggs (range 3–7). Incubation lasts 17–20 days, and both sexes participate in incubating and brood rearing.

BLRA eggs hatch one at a time, and the young are semiprecocial, requiring brooding by at least one parent for the first few days after hatching (Heaton 1937 *in* Eddleman et al. 2020). Along the LCR, Flores and Eddleman (1993) followed the fate of two nests, where they recorded parents and young leaving the nest within 24 hours after the clutches had hatched completely.

The habitat structure explains BLRA habitat use better than plant composition, with water depth being a critical factor (Flores 1991; Flores and Eddleman 1993). In their study of BLRA along the LCR, Flores and Eddleman (1993) found that BLRA selected areas with high stem densities and canopy coverage in shallow water (average depth = 2.2 centimeters) close to upland vegetation. Limited information is available about BLRA food habits, though they are likely opportunistic foragers (Eddleman et al. 2020). Small aquatic and terrestrial invertebrates, as well as seeds, are the main food items for BLRA (Eddleman et al. 2020). They likely feed during the day and are active throughout the day (Flores 1991).

CONCEPTUAL ECOLOGICAL MODEL PURPOSES

This update does not propose any changes to this section of chapter 1; however, when the CEMs are fully updated, chapter 1 should be revised to indicate that the CEM methodology followed here is a crucial foundation for carrying out effects analyses as described by Murphy and Weiland (2011, 2014) and illustrated by Jacobson et al. (2016).

CONCEPTUAL ECOLOGICAL MODEL STRUCTURE FOR BLRA

No change. This will not be updated for the existing CEMs.

Updates to Chapter 2 – BLRA Life-Stage Model

This update standardizes the names of BLRA life stages by switching to the plural noun form for each name, consistent with the other LCR MSCP conceptual ecological model updates. The names of the original life-stage outcomes are standardized as follows: Survivors changes to Survival for all three life stages; Offspring and Reproduction change to Fertility; and this update drops the word "rate" from the names of life-stage outcomes because all life-stage outcomes are rate variables by definition. Table 1 and figure 1 are updated accordingly (see below, "Update to Life-Stage Model Summary").

UPDATE TO INTRODUCTION TO THE BLRA LIFE CYCLE

The BLRA is one of two subspecies of black rail that breeds in North America (Eddleman et al. 2020). Discovered relatively recently along the LCR (Snider 1969), the majority of known populations of BLRA found within the LCR MSCP boundaries prior to 2008 were in Reaches 5 and 6 (Reclamation 2008). Since 2008, BLRA have been detected in almost all years in Topock Gorge and other locations within Reach 3 (Kahl, Jr. 2013b, 2016, 2018b, 2019). A BLRA (one individual) was found for the first time at the Big Bend Conservation Area (Reach 3) in 2018 (Kahl, Jr. 2018a). Other conservation areas in which the species has been recently encountered include Hart Mine Marsh (Reach 4) in 2014 and Imperial Ponds (Reach 5) in 2014 and 2017 (Harrity and Conway 2017; Ronning and Kahl, Jr. 2017). The black rail is the smallest rail in North America and is a very secretive bird. Little information is available on pair formation, but the species may form pairs as early as February based on when calling is initiated (Flores 1991).

The focus is on three life stages occurring within LCR MSCP lands—eggs/nestlings, juveniles, and breeding adults. The egg and chick phases of development have been combined into a single life stage in the model even though they undergo different processes—e.g., eggs do not need to eat or molt—because both eggs and chicks occupy the same nest; therefore, management focused on the nest will cover eggs and chicks.

The BLRA is a year-round resident along the LCR (Flores 1991), so the focus of habitat management for the species is on both the breeding and wintering grounds. There is evidence for occasional small-scale dispersal (< 200 kilometers) in BLRA populations between the San Francisco Bay and adjacent Sierra foothill populations (Hall and Beissinger 2017). The extent and importance of seasonal migration is not known, so the focus of this study is on management activities within the scope of Reclamation's responsibilities.

UPDATE TO BLRA LIFE STAGE 1 – EGGS/NESTLINGS

We consider the eggs/nestlings stage to be the first in the life cycle of BLRA. It begins when the egg is laid and ends either when the young fledge or the nest fails. Nesting ranges from March to July, though later nesting records may represent second nests (Eddleman et al. 2020). Flores and Eddleman (1993) recorded a mean clutch size for five nests in Arizona of 4.8 eggs (range 3–7), and a wider sample of BLRA had a mean clutch size of 6.0 eggs (range 3–8). A recently documented nest from the Imperial National Wildlife Refuge had seven eggs (Harrity and Conway 2017). The incubation period of five nests in Arizona was 17–20 days (Flores and Eddleman 1993).

Both males and females participate in incubation. Chicks are thought to hatch one at a time and require brooding by one parent for the first few days after hatching (Eddleman et al. 2020). The life-stage outcome from the eggs/nestlings stage is the survival of eggs and associated chicks until they become juveniles. It is important to note that the outcome of the nest stage is inherently tied to the behavior and condition of the parents.

UPDATE TO BLRA LIFE STAGE 2 – JUVENILES

This life stage begins when the chick has become independent from the parents and ends when the individual reaches sexual maturity. The precise timing of the end of this life stage for BLRA is unknown but is presumed to be around 1 year of age (Taylor and van Perlo 1998). While there is a tremendous amount of overlap in the biological activities and processes, habitat elements, and controlling factors affecting both the juveniles and breeding adults life stages, we felt that differences in behavior and the way in which BLRA in these life stages interact with the environment were potentially significantly different enough to warrant the split.

UPDATE TO BLRA LIFE STAGE 3 – BREEDING ADULTS

This life stage begins when the rail reaches sexual maturity and ends when the rail stops reproducing. It is estimated that adult BLRA reach sexual maturity around 1 year of age (Taylor and van Perlo 1998). Breeding begins in February with pair formation (DUDEK 2014). Nesting occurs from March through July, with peak nesting in early May (Eddleman et al. 2020). BLRA are known to renest (Eddleman et al. 2020).

The life-stage outcomes for breeding adults are survival and reproduction—here defined as the production of eggs. Most studies of bird demography define fecundity—or the reproductive rates of adults—as the number of offspring fledged (Etterson et al. 2011). We have separated the nest stage from adult fecundity to more clearly display the information regarding nest success so that it can be better assessed by management. Therefore, adult reproduction involves the acts of pairing, site selection, nest building, and the production of eggs.

UPDATE TO LIFE-STAGE MODEL SUMMARY

Table 1 and figure 1 are updated with new life-stage names.

Table 1.—(Revision of original table 1) BLRA life stages and life-stage outcomes in the LCR ecosystem

Life stage	Life-stage outcome(s)
1. Eggs/nestlings	• Egg/nestling survival
2. Juveniles	• Juvenile survival
3. Breeding adults	• Breeding adult survival • Breeding adult fertility

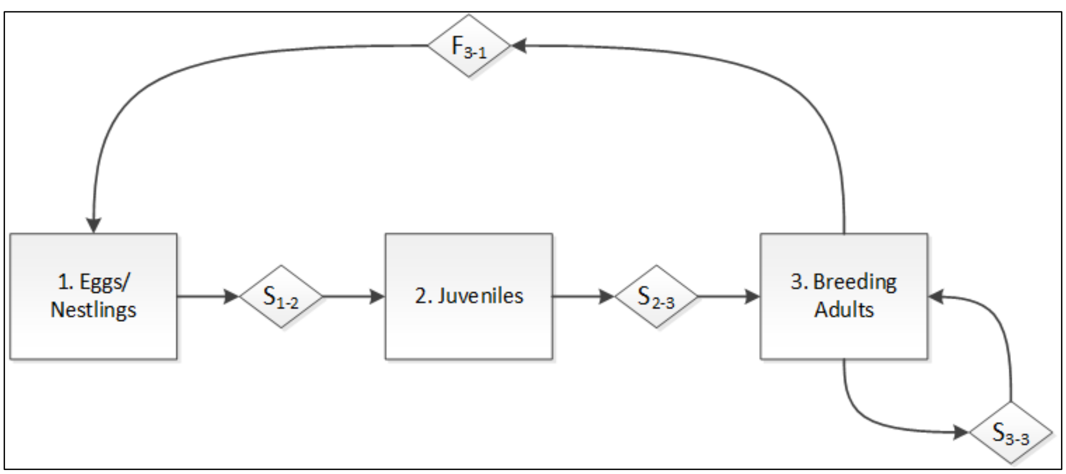

Figure 1.—(Revision of original figure 1) Proposed BLRA life history model. Squares indicate life stages, and diamonds indicate life-stage outcomes. $S_{1\text{-}2}$ = survival rate, Eggs/Nestlings; $S_{2\text{-}3}$ = survival rate, Juveniles; $S_{3\text{-}3}$ = survival rate, Breeding Adults; and $F_{3\text{-}1}$ = fertility, Breeding Adults.

Updates to Chapter 3 – Critical Biological Activities and Processes

This update identifies nine critical biological activity or processes that affect one or more BLRA life stages. The original BLRA conceptual ecological model (Marty and Unnasch 2015) identified eight. This update changes the name of one critical biological activity and process, Molt, replacing it with Molting, for consistency with the other LCR MSCP conceptual ecological model updates; splits one critical biological activity and process, Predation, into two separate activities and processes, Nest Predation and Predation, for consistency with other LCR MSCP conceptual ecological model updates; and updates the discussion of seven critical biological activities and processes. Table 2 lists the nine critical biological activity or processes in this update, their distribution across life stages, and indicates which are new to this update or renamed from the original BLRA conceptual ecological model.

Table 2.—(Revision of original table 2) Critical biological activities and processes by life stage
(Xs indicate that the critical biological activity or process is applicable to that life stage.)

Life stage ➔ **Critical biological activity or process ➔**	**Eggs/nestlings**	**Juveniles**	**Breeding adults**
Chemical stress	X	X	X
Disease	X	X	X
Eating	X		
Foraging		X	X
Molting (*replaces molt*)	X	X	X
Nest attendance			X
Nest predation (*new*)	X		
Nest site selection			X
Predation		X	X

CHEMICAL STRESS

The discussion of this critical biological activity or process is updated as follows:

BLRA in every life stage are vulnerable to stress and mortality due to exposure to harmful chemicals, including selenium, mercury, and pesticides/herbicides. Environmental contaminants such as selenium and mercury may have negative impacts on BLRA populations due to the bioaccumulation of these chemicals (Ackerman et al. 2012; Eagles-Smith et al. 2016; Tsao et al. 2009a). The effects of chemical contaminants such as pesticides/herbicides on BLRA populations along the LCR are virtually unknown, but slightly elevated selenium levels were found in LCR birds and eggs analyzed in 1988 (Flores and Eddleman 1993). No information is available regarding the impacts of chemical contamination on BLRA along the LCR; however, other species, including California (*Rallus obsoletus obsoletus*) and Yuma Ridgway's rails (*R. obsoletus yumanensis*) are known to have elevated levels of mercury (Ackerman et al. 2012; Lonzarich et al. 1992) and selenium (Eddleman 1989) in their feathers and tissues – and are capable of transferring contaminants from parents to eggs (Ackerman et al. 2016). Furthermore, a direct link between mercury contamination and reduced reproductive success in California clapper rails, due to fetal deformities and other embryonic pathologies, has been reported by Schwarzbach et al. (2006). Rusk (1991) measured selenium concentrations in sediment, invertebrates, and two marsh bird species: Virginia rails (*R. limicola*) and least bitterns (*Ixobrychus exilis*) along the LCR. She concluded that adult marsh bird species (and presumably juveniles) along the LCR were at low risk for mortality but moderate to high risk of teratogenicity.

DISEASE

The definition of this critical biological activity or process remains unchanged. No new information was located on disease patterns or consequences among BLRA in the Lower Colorado River Valley or elsewhere.

EATING

The discussion of this critical biological activity or process is updated as follows:

This process only applies to the eggs/nestlings life stage because the chick must eat to stay alive and develop but does not actively forage within its environment in the same way as juveniles and breeding adults. A chick's ability to eat during the first weeks of life is determined by the foraging and provisioning rate of its parents. Some elements, such as siblings, number of chicks in the nest, and genetic diversity, are not traditionally considered aspects of habitat but are included in this section because of their effects on critical biological activities and processes.

FORAGING

The discussion of this critical biological activity or process is updated as follows:

BLRA forage in marsh habitat on terrestrial and aquatic invertebrates (Eddleman et al. 2020; Repking and Ohmart 1977). Foraging is done by chicks, juveniles, and breeding adults, but it is important to note that foraging by the parents affects the provisioning rate to chicks and nest attendance by adults.

MOLTING

This critical biological process formerly named Molt is renamed Molting for consistency with other CEMs. The discussion of this critical biological activity or process is updated as follows:

Molt is one of the most significant biological activities and processes undertaken by bird species, and successful completion of various molts during a birds' lifetime is critical to all life stages (Howell 2010). BLRA nestlings molt from natal down into juvenal plumage in about 6 weeks, though this timing is uncertain (Eddleman et al. 2020). Molting is an energetically costly process that may make nestlings more susceptible to death when resources are scarce (Gill et al. 2019; Howell 2010). Juveniles undergo a partial to incomplete pre-basic (pre-formative) molt between July and September. Adults undergo a complete pre-basic molt after breeding (July – September) each year on their breeding grounds (Pyle 2008). Adults lose their wing and tail feathers simultaneously during this molt and are flightless for 3 to 4 weeks, making them more susceptible to predation (Eddleman et al. 2020; Flores 1991). Adult birds apparently have a partial pre-alternate molt between February and April (Eddleman et al. 2020).

NEST ATTENDANCE

The discussion of this critical biological activity or process is updated as follows:

Adequate nest attendance is important for successful reproduction. Both parents incubate the eggs in the nest and are responsible for feeding of the young (Eddleman et al. 2020). Breeding adults attend the nest, and this affects the survival of the nestlings. A recent report by Jedlikowski and Brambilla (2017) indicates that home range size is affected by nest attentiveness for the water rail (*R. aquaticus*) – which, like BLRA (Tsao et al. 2009b), has females that are more involved in egg incubation and, thus, have smaller home ranges than males. However, differences between male and female nest attendance are not currently addressed in the CEM.

NEST PREDATION

This critical biological activity or process has been added as a separate activity or process, distinct from predation, for consistency with other CEMs.

Nest predation is a threat to BLRA in the eggs/nestlings life stage, and it obviously affects survival. Potential nest predators include rats (*Rattus* spp.) and foxes (Eddleman et al. 2020); chicks may be killed by red fire ants (*Solenopsis invicta*) (Legare and Eddleman 2001).

NEST SITE SELECTION

The discussion of this critical biological activity or process is updated as follows:

Nest site selection is important for reproductive success. Nest success varies spatially as a result of vegetation characteristics, food availability, predator types and densities, hydrology, and other factors (Eddleman et al. 2020; Flores and Eddleman 1993). Various aspects of local hydrology are critical for nest site selection of BLRA, including depth and fluctuation rates of water levels, timing and severity of seasonal flooding, and the amount of open water areas, to name a few (DUDEK 2014; Eddleman et al. 2020). The plant species composition preferred by nesting BLRA along the LCR appears to be dense bulrush (*Schoenoplectus* spp.) stands and grasses (Repking and Ohmart 1977). Flores (1991) documented BLRA using microhabitats with very high stem densities of plants. Nests are placed on top of moist soil or above shallow water areas and constructed on sites with higher elevations than the surrounding habitat (BIO-WEST, Inc. 2005; Eddleman et al. 2020). From observations of BLRA in Florida, water level and hydrology are most likely the two factors that have the greatest impact on nest site selection and nesting success (Legare and Eddleman 2001). Similar conclusions have been drawn for other rallids (Clauser and McRae 2016; Schwarzbach et al. 2006; Valdes et al. 2016).

PREDATION

This critical biological activity or process has been modified to only include the juveniles and breeding adults life stages, for consistency with other CEMs, and is updated as follows:

Predation is a threat to BLRA in the juveniles and breeding adults life stages, and it obviously affects survival. Common predators of BLRA include northern harriers (*Circus hudsonius)*, great egrets (*Ardea alba)*, great blue herons (*A. herodias*), ring-billed gulls (*Larus delawarensis*), great horned owls (*Bubo virginianus*), and short-eared owls (*Asio flammeus*) (Butler et al. 2014; Eddleman et al. 2020). Other predators have been rarely documented, though feral cats (*Felis silvestris catus*) are known predators of BLRA in California (Evens and Page 1986) and red foxes (*Vulpes vulpes*) of clapper rails (Cassazza et al. 2014).

Updates to Chapter 4 – Habitat Elements

This update identifies 15 habitat elements that affect 1 or more critical biological activity or processes across 1 or more BLRA life stages. The original BLRA conceptual ecological model (Marty and Unnasch 2015) identified 14 habitat elements. This update standardizes the names of two habitat elements, with Brood Size becoming Brood/Litter Size and Predator Density becoming Predators, renames two habitat elements (Parental Nest Attendance and Plant Species Composition) for consistency with other CEMs into Parental Care and Vegetation Community Type, respectively, adds one new habitat element (Nest Predators) by separating it from Predators, deletes one habitat element (Invertebrate Community Composition) by merging it with Food Availability, splits one habitat element (Genetic Diversity and Infectious Agents) into two separate elements, and updates the discussion of eight habitat elements. Table 3 lists the 15 habitat elements in this update, indicates the critical biological activity or processes they *directly* affect across all BLRA life stages, and indicates which habitat elements are new to this update or renamed from the original BLRA conceptual ecological model.

Table 3.—(Revision of original table 3) Habitat elements directly affecting critical biological activities and processes
(Xs indicate that the habitat element is applicable to that critical biological activity or process.)

Critical biological activity or process ➔ **Habitat element 🡻**	**Chemical stress**	**Disease**	**Eating**	**Foraging**	**Molting**	**Nest attendance**	**Nest predation**	**Nest site selection**	**Predation**
Anthropogenic disturbance				X		X	X	X	X
Brood/litter size (*replaces brood size*)				X		X			
Food availability				X		X		X	
Genetic diversity (*replaces genetic diversity and infectious agents*)		X							
Infectious agents (*new*)		X							
Local hydrology							X	X	X
Matrix community	X			X			X	X	X
Nest predators (*new*)						X	X	X	
Parental care (*replaces parental nest attendance*)			X				X		X
Patch size				X			X	X	X
Predators (*replaces predator density*)				X		X	X	X	X
Residual vegetation density				X				X	
Site topography								X	
Vegetation community type (*replaces plant species composition*)				X				X	
Vegetation density				X			X	X	X

ANTHROPOGENIC DISTURBANCE

This habitat element is updated as follows:

Full name: **Human activity within or surrounding a given habitat patch, including noise, pollution, and other disturbances associated with human activity**. This element refers to the existence and level of human disturbance within proximity of BLRA habitat. These human disturbances may be a cause for rail decline along the LCR in areas that are in proximity to development and/or areas that receive varying levels of human use. Human activities typically affect the behavior of individual birds, though chronic disturbance can impact habitat quality more significantly as well. Anthropogenic disturbance, including noise from human recreation and activity of researchers, may impact BLRA activity (DUDEK 2014).

BROOD/LITTER SIZE

This habitat element replaces the original Brood Size; otherwise, no changes are made because no new information was located on brood/litter size among BLRA in the Lower Colorado River Valley or elsewhere.

FOOD AVAILABILITY

This habitat element now includes the former habitat element of Invertebrate Community Composition. The discussion of Food Availability is updated as follows:

Full name: **The abundance of food available for adults and their young**. This element refers to the taxonomic and size composition of the invertebrates that an individual BLRA will encounter during the eggs/nestlings, juveniles, and breeding adults stages as well as the density and spatial distribution of the food supply in proximity to the nest location. The abundance and condition of the food supply affects adult health as well as the growth and development of the young during the eggs/nestlings and juveniles stages. Chicks rely on their parents for nutrition for a very brief period before they begin to forage independently.

The composition of the aquatic and terrestrial invertebrate community directly affects BLRA prey abundance and foraging activity. Though foraging behavior in BLRA is poorly understood, BLRA appear to be opportunistic foragers, known to eat a mix of terrestrial and aquatic invertebrates (Eddleman et al. 2020). BLRA are thought to shift their habitat use depending on the seasonal availability of prey (BIO-WEST, Inc. 2005).

GENETIC DIVERSITY

The habitat element of Genetic Diversity and Infectious Agents has been separated into two distinct habitat elements. This discussion of Genetic Diversity is updated as follows:

Full name: **The genetic diversity of BLRA individuals**. This element refers to the genetic homogeneity versus heterogeneity of a population during each life stage. The greater the heterogeneity, the greater the possibility that individuals of a given life stage will have genetically encoded abilities to survive their encounters with the diverse stresses presented by their environment and/or take advantage of the opportunities presented. Habitat fragmentation can disrupt a species' ability to disperse and thus reduce a population's genetic diversity. As salt marsh ecosystems are particularly susceptible to fragmentation from such pressures as the development of agricultural lands, urbanization, and climate change induced sea level rise, a loss of genetic diversity for BLRA and other marsh birds is of particular concern, as demonstrated by the genetic structuring of Ridgway's rail (*R. obsoletus*) populations in the salt marsh fragments of the San Francisco Bay region (Wood et al. 2017).

INFECTIOUS AGENTS

The habitat element of Genetic Diversity and Infectious Agents has been separated into two distinct habitat elements. The discussion of Infectious Agents is updated as follows:

Full name: **The types, abundance, and distribution of infectious agents and their vectors**. This element refers to the spectrum of viruses, bacteria, fungi, and parasites that individual BLRA are likely to encounter during each life stage. No information is available on diseases or parasites for BLRA (Eddleman et al. 2020). However, a severe trombiculid mite infestation of Yuma Ridgway's rails at the Imperial National Wildlife Refuge (92% or 48 of 52 birds) has been found by Harrity and Conway (2019) in the same marsh that BLCA occupy. Although this mite has not been documented in BLRA, primarily because none were captured, it could be a potential emerging threat to BLRA (Harrity and Conway 2019).

LOCAL HYDROLOGY

This habitat element is updated as follows:

Full name: **Aspects such as the depth and fluctuations of standing water or the presence of adjacent water bodies, the timing and volume of floods, depth to the water table, and soil moisture levels**. This element refers to anything that affects local water fluctuations, such as the proximity of water to the nesting habitat, elevation, irrigation practices, and soil texture. The local hydrological conditions of a given patch might be the single most important determinant of BLRA habitat quality because they affect other aspects of habitat such as abundance of prey and vegetation structure. Various aspects of local hydrology are critical for nest site selection, including the depth and fluctuation rates of water levels and the timing and severity of seasonal flooding, to name a few (DUDEK 2014; Eddleman et al. 2020; Flores and Eddleman 1995; Nadeau and Conway 2015; Nadeau et al. 2011; Richmond et al. 2010).

The optimum water depth for BLRA is saturated soil to 100 millimeters (mm), ranging up to 130–190 mm (Nadeau and Conway 2015). Including a slope in the managed wetland area between the wetland and adjacent upland also contributes to management flexibility and allows rails to select their preferred depth (Dodge 2019; Nadeau and Conway 2015). Nadeau and Conway (2015) also point out that there is a tradeoff between the amount of water needed and water depth; shallower depths may allow the maintenance of BLRA habitat in areas or during times when water availability is limited. Whereas other marsh birds, such as Yuma Ridgway's rails, have been reported to be able to persist in areas of flooding in the LCR (Dodge and Rudd 2017), perhaps by building their nests up with additional material or moving their nests to higher ground when necessary (Eddleman and Conway 2020; Rush et al. 2020). BLRA are believed to be sensitive to abrupt, unexpected changes in water levels (BIO-WEST, Inc. 2005; Eddleman et al. 2020; Nadeau et al. 2011). However, the known occurrence of BLRA in tidal or tidally influenced areas suggests that some level of systematic or regular variation in water levels may be acceptable, if not preferable (Dodge 2019). Additionally, habitat created from leaking water storage and conveyance infrastructure may be critical for the survival of BLRA along the LCR (Evens et al. 1991).

MATRIX COMMUNITY

The definition of this habitat element remains unchanged. No new information was located on the matrix community among BLRA in the Lower Colorado River Valley or elsewhere.

NEST PREDATORS

This habitat element is added for consistency with other CEM updates.

Full name: **The abundance and distribution of nest predators**. This element refers to a set of closely related variables that affect the likelihood that different kinds of predators will encounter and successfully prey on BLRA during the eggs/nestlings life stage. The variables of this element include the species and size of the fauna that prey on BLRA during the eggs/nestlings life stage, the density and spatial distribution of these fauna in the habitat used by BLRA, and whether predator activity may vary in relation to other factors (e.g., time of day, patch size and width, matrix community type).

PARENTAL CARE

This habitat element replaces the original Parental Nest Attendance. The discussion of Parental Care is updated as follows:

Full name: **The ability of parents to care for young during the eggs/nestlings stage and after hatching**. This element refers to the capacity of both parents to share nesting and brood-rearing responsibilities until fledging. The chicks are semiprecocial and only receive care from parents for a short period after hatching (Eddleman et al. 2020). Parental care in BLRA is poorly known, but it is provided by one or both parents and may include providing shelter and warmth, providing food, warding off predators, and teaching the young necessary life skills. The better the quality of the parental care, the healthier the condition and, therefore, the higher the rate of survival of the offspring, other things being equal. Parental care is affected by food availability and the presence of predators and competitors.

PATCH SIZE

This habitat element is updated as follows:

Full name: **The size of wetland habitat patches**. This element refers to the areal extent of a given patch of wetland vegetation. Patch size may affect the number of breeding pairs that an area can support as well as the density of predators and competitors. Few studies are available that address the effect of patch size on BLRA activity directly, though Flores (1991) recorded year-round home ranges between 0.11 and 1.8 hectares (ha) in Arizona. In general, home ranges increased outside of the breeding season. Tsao et al. (2015) have reported the association of BLRA in the Sacramento-San Joaquin Delta with patch sizes ranging from small in-channel islands (approximately 0.99 ha) to larger wetland habitats (with a median of 10.19 ha), but few studies are available that address patch size in the LCR or the effect of patch size on BLRA activity directly. Nonetheless, Flores (1991) recorded year-round home ranges between 0.11 and 1.8 ha in Arizona—which is in keeping with the home range of BLRA in the San Francisco Bay (Tsao et al. 2009b)—and showed that, in general, home ranges increased outside of the breeding season.

Though BLRA demonstrate relatively small home ranges, they are thought to prefer larger wetland patches (Roach and Barret 2015; Spautz et al. 2005), as they likely provide better food resources and protection from tidal and storm surges (Tsao et al. 2009b). Tsao et al. (2015) speculate that a range of patches of all sizes is valuable in regions with a limited availability of wetlands, as they may be used by BLRA as part of a larger matrix where small isolated patches alone would not provide the necessary cover or food resources.

PREDATORS

This habitat element replaces the original, Predator Density, for clarity and consistency among models. The discussion of Predators is updated as follows:

Full name: **The abundance and distribution of species that depredate BLRA during the juveniles and breeding adults life stages**. This element refers to a set of closely related variables that affect the likelihood that different kinds of predators will encounter and successfully prey on BLRA during the juveniles and breeding adults life stages. The variables of this element include the species and size of the fauna that prey on BLRA during these life stages, the density and spatial distribution of these fauna in the habitat used by BLRA, and whether predator activity may vary in relation to other factors (e.g., time of day, patch size and width, matrix community type).

RESIDUAL VEGETATION DENSITY

The definition of this habitat element remains unchanged. No new information was located on residual vegetation density among BLRA in the Lower Colorado River Valley or elsewhere.

SITE TOPOGRAPHY

This habitat element is updated as follows:

Full name: **The topographic relief of the land surrounding the nest**. The preferred habitat of BLRA includes shallow, gently sloping shorelines and appropriate dense vegetation (Repking and Ohmart 1977). As described above, restoration sites are recommended to possess saturated soils, a very gradual slope at the upland-wetland ecotone, and a stable water depth of approximately saturated soil to 100 mm (Nadeau and Conway 2015).

VEGETATION COMMUNITY TYPE

This habitat element replaces the original, Plant Species Composition, for consistency with other CEMs. The discussion of Vegetation Community Type is updated as follows.

Full name: **The composition of plant species in the plant community**. This element refers to the species composition of the plant community where BLRA are active. The plant species composition preferred by nesting BLRA along the LCR appears to be dense bulrush stands and grasses (Repking and Ohmart 1977). Flores (1991) documented BLRA using microhabitats with very high stem densities of plants.

Flores and Eddleman (1995) suggest that habitat structure, rather than plant species composition, better explains BLRA use of habitat; however, the two are difficult to separate. Generally, high stem densities of bulrush and higher cover of residual vegetation are considered suitable habitat for BLRA (Flores 1991; Repking and Ohmart 1977). In a study of BLRA habitat use of restored habitat in the Imperial National Wildlife Refuge, Nadeau et al. (2011) found that BLRA were more likely to be found in areas with higher densities of chairmaker's bulrush (*Schoenoplectus americanus*) and low densities of river bulrush (*Schoenoplectus robustus*). They also found a slight negative association of BLRA use and southern cattail (*Typha domingensis*).

In addition, the results of Tsao et al. (2015) indicate that, at least in the Sacramento-San Joaquin Delta, BLRA will make use of tall (> 1 to 5 meters) emergent wetland vegetation (*Bolboschoenus* spp., *Typha* spp., *Phragmites australis)* and woody riparian shrub species (*Cornus sericea, Salix lasiolepis,* and *S. exigua)*. They suggest that the tall, dense woody cover of riparian species provides refuge from both high tides and predators.

VEGETATION DENSITY

The definition of this habitat element remains unchanged. No new information was located on vegetation density among BLRA in the Lower Colorado River Valley or elsewhere.

Updates to Chapter 5 – Controlling Factors

This update identifies eight controlling factors that affect one or more habitat elements and/or critical biological activity or processes across the three BLRA life stages. The original BLRA conceptual ecological model (Marty and Unnasch 2015) identified seven controlling factors. This update adds one controlling factor, On-Site Water Management, standardizes the name of the controlling factors Pesticide/Herbicide Application and Habitat Restoration, replacing them with Pesticide Application and Habitat Management and Restoration, respectively, and updates the discussion of four controlling factors. Table 4 lists the eight controlling factors in this update, indicates which habitat elements they *directly* affect and which controlling factors are new to this update or renamed from the original BLRA conceptual ecological model.

Table 4.—(Revision of original table 4) Habitat elements directly affected by controlling factors (Xs indicate that the habitat element is applicable to that controlling factor.)

Controlling factor ➔ **Habitat element 🡻**	**Fire management**	**Grazing**	**Habitat management and restoration (*replaces habitat restoration*)**	**Mechanical soil disturbance**	**Nuisance species introduction and management**	**On-site water management (*new*)**	**Pesticide application (*replaces pesticide/ herbicide application*)**	**Water storage-delivery system design and operation**
Anthropogenic disturbance	N/A*							
Brood/litter size	N/A*							
Food availability					X		X	
Genetic diversity	N/A*							
Infectious agents	N/A*							
Local hydrology			X					X
Matrix community			X					
Nest predators	N/A*							
Parental care	N/A*							
Patch size	X		X					
Predators	N/A*							
Residual vegetation density	X	X	X	X				
Site topography			X	X				X
Vegetation community type	X	X	X	X	X	X		X
Vegetation density	X	X	X	X		X		

* N/A values suggest that none of the identified controlling factors *directly* affect the habitat element.

FIRE MANAGEMENT

This controlling factor is updated as follows:

This factor addresses any fire management (whether prescribed fire or fire suppression) that may occur along the LCR that could affect BLRA or their habitat. Effects may include creation of habitat that supports or excludes BLRA, a reduction in the food supply of invertebrates, or support of species that pose threats to BLRA such as predators, competitors, or carriers of infectious agents. Although typically not a major threat in most wetland habitats, fire has the potential to be a source of mortality during the breeding season (Reclamation 2008). Fire may have positive impacts on habitat for other rail species along the LCR by removing decadent vegetation and encouraging growth of early successional emergent vegetation, but a study looking at the effects of fire in late winter or early spring (February – April) on rails along the LCR did not detect an effect on BLRA (Conway et al. 2010). An earlier study by Conway and Nadeau (2005) indicated BLRA were more abundant in burned areas. In Kansas, black rails were shown to prefer areas burned every 2 years (Kane 2011 *in* Butler et al. 2014).

Climate change is also projected to affect fire frequency along the LCR (U.S. Fish and Wildlife Service 2013).

GRAZING

This controlling factor is updated as follows:

This factor addresses grazing by wild, domesticated, and feral animals in marsh habitat along the LCR that could affect BLRA or their habitat. Currently, grazing is minimal in LCR MSCP marsh habitat. Since BLRA occupy habitat on the fringes of marshes, livestock grazing near marshes occupied by BLRA may impact the species (Eddleman 1989). Grazing alters the vegetation structure through loss of emergent cover via trampling and direct removal (Butler et al. 2014). In the Sierra Nevada foothills, grazing was found to positively influence BLRA occupancy at irrigated marshes but negatively influence occupancy at non-irrigated sites (Richmond et al. 2012).

Habitat Management and Restoration

This controlling factor is updated from the original, Habitat Restoration. The discussion of Habitat Management and Restoration is updated as follows.

This factor addresses activities to restore wetland and riparian habitat along the LCR, including manipulation of soils, vegetation, and water to restore structure and function to the community. The design and management of restored marsh habitat affects a number of critical factors related to habitat suitability for CLRA, including vegetation community characteristics and hydrology (Nadeau et al. 2011). In particular, the probability of BLRA occupancy in restored wetlands was positively correlated with chairmaker's bulrush and southern cattail, negatively correlated with river bulrush, and highest if the water depth was between -44 and 40 mm (Nadeau et al. 2011).

Along the Atlantic coast, BLRA occupancy was higher in managed impoundments compared to unmanaged, tidal marsh (Roach and Barret 2015). Along the LCR, Trathnigg and Phillips (2015) demonstrated that restoring structurally complex habitats, including a diverse understory, in riparian and marsh habitats in Yuma East Wetlands along the LCR in Arizona led to an increase in overall bird richness and abundance. While they did not detect any BLRA in the restored areas, they did detect breeding Yuma Ridgway's rails and speculate that BLRA may colonize these areas in the future; therefore, that these restoration techniques may also benefit BLRA.

Mechanical Soil Disturbance

The definition of this controlling factor remains unchanged. No new information was located on mechanical soil disturbance among BLRA in the Lower Colorado River Valley or elsewhere.

Nuisance Species Introduction and Management

This controlling factor is updated as follows:

This factor addresses the intentional or unintentional introduction of nuisance species (animals and plants) and their control that affects BLRA survival and reproduction. Nuisance species may infect, prey on, compete with, or present alternative food resources for BLRA during one or more life stages; cause other alterations to the wetland food web that affect BLRA; or affect physical habitat features such as vegetation structure and cover. For example, feral pigs (*Sus scrofa*) have been observed in marsh habitat at Topock Gorge and Beal Lake within the Havasu National Wildlife Refuge (J. Kahl, Jr. 2015, personal communication).

ON-SITE WATER MANAGEMENT

This controlling factor is added to the CEM.

This factor addresses the types, frequencies, and durations of official activities that affect the delivery and distribution of regulated water within sites managed to support BLRA habitat. In particular, this addresses water management for ponds and marshes maintained by LCR, including areas such as the Big Bend, Hart Mine Marsh, and Imperial Ponds Conservation Areas, at which BLRA have been found during surveys (Kahl, Jr. 2013a, 2018a; Ronning and Kahl, Jr. 2017, 2018). BLRA rely on consistent water levels during the breeding season (Nadeau et al. 2011), and their abundance at a site will vary over time, depending on water levels. In particular, the ability to stabilize water depths through automated irrigation seems to create habitat preferred by BLRA (Nadeau et al. 2011).

On-site water management in the LCR may include actions to reduce or terminate water applications at a site (e.g., to reallocate water to other sites within the limits of Reclamation or another agency’s water rights). The amount and consistency of water provided through pond and marsh water level management directly affects water depth, water chemistry, vegetation density and species composition, and the overall suitability of a wetland for nesting BLRA.

PESTICIDE APPLICATION

The definition of this controlling factor remains unchanged. No new information was located on pesticide application among BLRA in the Lower Colorado River Valley or elsewhere.

WATER STORAGE-DELIVERY SYSTEM DESIGN AND OPERATION

This controlling factor is updated as follows:

The LCR consists of a chain of reservoirs separated by flowing reaches. The water moving through this system is highly regulated for storage and delivery (diversion) to numerous international, Federal, State, Tribal, and municipal users and for hydropower generation. The amount of water released or stored affects water levels and, therefore, distance to water, soil moisture, and other hydrological conditions. The dynamic nature of a free-flowing river creates a mosaic of riparian and wetland habitats, and thus, a natural flow regime may be beneficial to some of the marsh species, such as the Yuma Ridgway's rail, along the LCR (Reclamation 2008). However, BLRA are much more sensitive to fluctuations in water levels and, therefore, may be negatively impacted by sudden and extreme changes in hydrology in the marsh habitat they occupy (BIO-WEST, Inc. 2005; Eddleman et al. 2020; Nadeau et al. 2011).

Additionally, leaky canals used for water delivery and agricultural irrigation runoff create seepage marshes – microhabitats that are preferred by BLRA (Evens et al. 1991). Repair of leaking infrastructure and lining of canals may negatively impact this seepage marsh habitat.

Updates to Chapter 6 – Conceptual Ecological Model by Life Stage

The following sections identify all changes made to the BLRA conceptual ecological model workbook other than changes that involve only updates to names. These latter changes are listed separately in table 5 (see "Summary of Standardization of Terms" at the end of this chapter). The items in each section of this chapter are arranged alphabetically. The abbreviations, CF for controlling factor, HE for habitat element, CAP for critical activity or process, and LSO for life-stage outcome are provided to identify component types where needed. Each item also identifies the life stage(s) to which the item applies.

NEW LINKS WITH CONTROLLING FACTORS AS CAUSAL AGENTS

- Grazing to Anthropogenic Disturbance (HE): This link was added for compatibility with other CEMs. *Applies to all life stages*.
- Grazing to Nuisance Species Introduction and Management (CF): This link was added due to the availability of new information and analysis. *Applies to all life stages*.
- Mechanical Soil Disturbance to Anthropogenic Disturbance (HE): This link was added due to the availability of new information and analysis. *Applies to all life stages*.
- On-Site Water Management to Vegetation Community type (HE): This link was added due to the availability of new information and analysis. *Applies to all life stages*.
- On-Site Water Management to Vegetation Density (HE): This link was added due to the availability of new information and analysis. *Applies to all life stages*.
- Water Storage-Delivery System Design and Operation to On-Site Water Management (CF): This link was added due to the availability of new information and analysis. *Applies to all life stages*.

DELETED LINKS WITH CONTROLLING FACTORS AS CAUSAL AGENTS

No change.

UPDATED LINKS WITH CONTROLLING FACTORS AS CAUSAL AGENTS

- Grazing to Residual Vegetation Density (HE): This link was updated due to the availability of new information and analysis. *Applies to all life stages*.

- Grazing to Vegetation Community type (HE): This link was updated due to the availability of new information and analysis. *Applies to all life stages*.

- Grazing to Vegetation Density (HE): This link was updated due to the availability of new information and analysis. *Applies to all life stages*.

NEW LINKS WITH HABITAT ELEMENTS AS CAUSAL AGENTS

- Anthropogenic Disturbance to Nest Predation (CAP): This new link was added due to new information. Anthropogenic disturbance should have an effect on nest predation. The link is hypothesized to be negative with no or an unknown threshold and unidirectional with proposed low intensity, spatial, and temporal scale; low predictability; and low understanding. *Applies to the eggs/nestlings life stage*.

- Anthropogenic Disturbance to Predation (CAP): This new link was added due to new information. Anthropogenic disturbance should have an effect on predation. The link is hypothesized to be negative with no or an unknown threshold and unidirectional with proposed low intensity, spatial, and temporal scale; low predictability; and low understanding. *Applies to the breeding adults and juveniles life stages*.

- Infectious Agents to Disease (CAP): This new link was added due to the separation of the formerly combined Genetic Diversity and Infectious Agents into two new habitat elements. Infectious agents such as pathogens and vectors in an environment affect transmission risk, and fewer infectious agents mean less likelihood of disease transmission. The link is hypothesized to be positive with no or an unknown threshold and unidirectional with proposed low intensity, spatial, and temporal scale; low predictability; and low understanding. *Applies to all life stages*.

- Matrix Community to Nest Predation (CAP): This new link was added due to new information. Surrounding land uses should have an effect on nest predation. The link is hypothesized to be complex and unidirectional with proposed low intensity and medium spatial and temporal scale, medium predictability, and medium understanding. *Applies to the eggs/nestlings life stage*.

- Matrix Community to Predation (CAP): This new link was added due to new information. Surrounding land uses should have an effect on predation. The link is hypothesized to be complex and unidirectional with proposed low intensity and medium spatial and temporal scale, medium predictability, and medium understanding. *Applies to the breeding adults and juveniles life stages*.

- Predators to Nest Attendance (CAP): This new link was added due to new information. Increased predator density should affect nest attendance. The link is hypothesized to be negative with no or an unknown threshold and unidirectional with proposed low intensity, spatial, and temporal scale; low predictability; and low understanding. *Applies to the breeding adults life stage*.

- Vegetation Density to Nest Predation (CAP): This new link was added due to new information. Vegetation density may have an effect on nest predation. The link is hypothesized to be complex and unidirectional with proposed low intensity, spatial, and temporal scale; low predictability; and low understanding. *Applies to the breeding adults and juveniles life stages*.

- Vegetation Density to Predation (CAP): This new link was added due to new information. Vegetation density may have an effect on predation. The link is hypothesized to be complex and unidirectional with proposed low intensity, spatial, and temporal scale; low predictability; and low understanding. *Applies to the eggs/nestlings life stage*.

DELETED LINKS WITH HABITAT ELEMENTS AS CAUSAL AGENTS

- Anthropogenic Disturbance to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

- Brood/Litter Size to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

- Food Availability to Food Availability (CAP): This link was deleted because the merger of the former standalone habitat element of Aquatic Faunal Composition with Food Availability created a redundant link. *Applies to all life stages*.

- Food Availability to Foraging (CAP): This link was deleted because the merger of the former standalone habitat element of Aquatic Faunal Composition with Food Availability created a duplicate link. *Applies to all life stages*.

- Food Availability to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

- Matrix Community to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

- Patch Size to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

- Predators to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

- Residual Vegetation Density to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

- Vegetation Community Type to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

UPDATED LINKS WITH HABITAT ELEMENTS AS CAUSAL AGENTS

- Food Availability to Foraging (CAP): This link was updated due to the merger of the former standalone habitat element of Aquatic Faunal Composition with Food Availability, which provided new information. *Applies to all life stages*.

- Genetic Diversity to Disease (CAP): This link was updated due to the separation of the formerly combined Genetic Diversity and Infectious Agents into two new habitat elements. *Applies to all life stages*.

NEW LINKS WITH CRITICAL ACTIVITIES/PROCESSES AS CAUSAL AGENTS

No change.

DELETED LINKS WITH CRITICAL ACTIVITIES/PROCESSES AS CAUSAL AGENTS

- Disease to Foraging (CAP): This link was deleted because the foraging critical activity and process no longer applies to the eggs/nestlings life stage. *Applies to the eggs/nestlings life stage*.

UPDATED LINKS WITH CRITICAL ACTIVITIES/PROCESSES AS CAUSAL AGENTS

- Nest Predation to Survival (LSO): This link was updated due to the separation of nest predation, which applies only to eggs/nestlings, from predation, which applies only to breeding adults and juveniles. *Applies to the eggs/nestlings life stage*.

NEW LINKS WITH LIFE-STAGE OUTCOMES AS CAUSAL AGENTS

No change.

Summary of Standardization of Terms

Table 5.—(New table for this update) Updated CEM component names
(Blue indicates new or revised items; orange indicates replaced items.)

BLRA conceptual ecological model updated terms, 2019	BLRA conceptual ecological model original terms, 2015–16
Life stages	
Eggs/Nestlings	Nest
Juveniles	Juvenile
Breeding Adults	Breeding Adults
Life-stage outcomes	
Survival	Survival
Fertility	Reproduction
Critical biological activities and processes	
Chemical Stress	Chemical Stress
Disease	Disease
Eating	Eating
Foraging	Foraging
Molting *(renamed)*	Molt
Nest Attendance	Nest Attendance
Nest Predation *(new)*	
Nest Site Selection	Nest Site Selection
Predation	Predation
Habitat elements	
Anthropogenic Disturbance	Anthropogenic Disturbance
Brood/Litter Size *(renamed)*	Brood Size
Food Availability *(revised)*	Food Availability
Genetic Diversity *(new)*	Genetic Diversity and Infectious Agents *(see Genetic Diversity; see Infectious Agents)*
Infectious Agents *(new)*	
	Invertebrate Community Composition *(see Food Availability)*
Local Hydrology	Local Hydrology
Matrix Community	Matrix Community
Nest Predators *(new)*	
Parental Care *(renamed)*	Parental Nest Attendance *(see Parental Care)*
Patch Size	Patch Size
Predators *(renamed)*	Predator Density *(see Predators)*
Residual Vegetation Density	Residual Vegetation Density
Site Topography	Site Topography
Vegetation Community Type *(renamed)*	Plant Species Composition *(see Vegetation Community Type)*
Vegetation Density	Vegetation Density
Controlling factors	
Fire Management	Fire Management
Grazing	Grazing
Habitat Management and Restoration *(renamed)*	Habitat Restoration
Mechanical Soil Disturbance	Mechanical Soil Disturbance
Nuisance Species Introduction and Management	Nuisance Species Introduction and Management
On-site Water Management *(new)*	
Pesticide Application *(renamed)*	Pesticide/Herbicide Application
Water Storage-Delivery System Design and Operation	Water Storage-Delivery System Design and Operation

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ATTACHMENT 1

California Black Rail (*Laterallus jamaicensis coturniculus* Ridgway) (BLRA) Habitat Data

Table 1-1.—California black rail habitat data

Habitat element	Value or range	Location	Reference
Anthropogenic Disturbance	No quantifiable values found in the literature.		
Brood/Litter Size	No quantifiable values found in the literature.		
Food Availability	No quantifiable values found in the literature.		
Genetic Diversity	No quantifiable values found in the literature.		
Infectious Agents	No quantifiable values found in the literature.		
Local Hydrology	Standing water < 3 centimeters (cm) deep.	Lower Colorado River	Flores and Eddleman 1995; Conway and Sulzman 2007
	Standing water < 2.5 cm; < 25% of substrate covered in water.	Lower Colorado River	Flores 1991
	-44–40 millimeters (mm) of water.	Imperial National Wildlife Refuge	Nadeau et al. 2011
	Prefer more stable water depths.	Imperial National Wildlife Refuge	Nadeau et al. 2011
	Maintain water depth between saturated soil and 100 mm.	Imperial National Wildlife Refuge	Nadeau and Conway 2015
	Restoration sites should include a very gradual slope at the upland-wetland ecotone, allowing rails to move position in response to changes in preferred water depth.	Lower Colorado River	Repking and Ohmart 1977; Nadeau and Conway 2015
	Leaky canal infrastructure creates seepage marshes that are important habitat.	Lower Colorado River	Evens et al. 1991
	Sensitive to sudden changes in water levels.	Lower Colorado River	Eddleman et al. 2020; Flores and Eddleman 1995; BIO-WEST, Inc. 2005; Nadeau et al. 2011
Matrix Community	No quantifiable values found in the literature.		
Nest Predators	No quantifiable values found in the literature.		
Parental Care	No quantifiable values found in the literature.		
Patch Size	Year-round home range mean ≤ 0.43 hectare (ha); range = 0.11 to 1.8 ha.	Lower Colorado River	Flores 1991
	Patch sizes ranging from small in-channel islands (approximately 0.99 ha) to larger wetland habitats (with a median of 10.19 ha).	Sacramento-San Joaquin Delta	Tsao et al. 2015
	It is thought that in regions with a limited availability of wetlands, a range of patches of different sizes is valuable, as they may be used to form a larger matrix.	Sacramento-San Joaquin Delta	Tsao et al. 2015

Table 1-1.—California black rail habitat data

Habitat element	Value or range	Location	Reference
Predators	No quantifiable values found in the literature.		
Residual Vegetation Density	Higher densities in areas with heavy matting of fallen vegetation.	Lower Colorado River	Repking and Ohmart 1977
Site Topography	Very gradual slope at the upland-wetland ecotone and a stable water depth of approximately saturated soil to 100 mm.	Lower Colorado River	Nadeau and Conway 2015
Vegetation Community Type	Plants most common where BLRA detected: common threesquare (*Schoenoplectus pungens)*, arrowweed (*Pluchea sericea)*, Fremont cottonwood (*Populus fremontii)*, seepwillow (*Baccharis salicifolia*), and mixed shrubs.	Lower Colorado River	Conway and Sulzman 2007
	Bulrush (*Schoenoplectus* spp.) and grasses.	Lower Colorado River	Repking and Ohmart 1977
	Promote chairmaker's bulrush (*Schoenoplectus americanus*) in shallow water areas (< 30 mm).	Imperial National Wildlife Refuge	Nadeau et al. 2011
	Tolerant of tamarisk (*Tamarix* spp.) cover < 67%.	Lower Colorado River	Conway and Sulzman 2007
	BLRA will make use of tall (> 1 to 5 meters) emergent wetland vegetation (*Bolboschoenus* spp., *Typha* spp., *Phragmites australis)* and woody riparian shrub species (*Cornus sericea, Salix lasiolepis, and S. exigua)*.	Sacramento-San Joaquin Delta	Tsao et al. 2015
Vegetation density	High stem densities.	Lower Colorado River	Flores 1991
	Probability of occupancy positively associated with stem density and height of chairmaker's bulrush and slightly negatively associated with stem density and height of southern cattail (*Typha domingensis*).	Imperial National Wildlife Refuge	Nadeau et al. 2011

ATTACHMENT 1 – LITERATURE CITED

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