Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2019 Updates to Yuma Clapper Rail (*Rallus longirostris yumanensis* Dickey) (CLRA) Basic Conceptual Ecological Model for the Lower Colorado River

Photo courtesy of the Bureau of Reclamation

BUREAU OF RECLAMATION

Work conducted under LCR MSCP Work Task G6

July 2020

Lower Colorado River Multi-Species Conservation Program Steering Committee Members

Federal Participant Group

Bureau of Reclamation
U.S. Fish and Wildlife Service
National Park Service
Bureau of Land Management
Bureau of Indian Affairs
Western Area Power Administration

Arizona Participant Group

Arizona Department of Water Resources
Arizona Electric Power Cooperative, Inc.
Arizona Game and Fish Department
Arizona Power Authority
Central Arizona Water Conservation District
Cibola Valley Irrigation and Drainage District
City of Bullhead City
City of Lake Havasu City
City of Mesa
City of Somerton
City of Yuma
Electrical District No. 3, Pinal County, Arizona
Golden Shores Water Conservation District
Mohave County Water Authority
Mohave Valley Irrigation and Drainage District
Mohave Water Conservation District
North Gila Valley Irrigation and Drainage District
Town of Fredonia
Town of Thatcher
Town of Wickenburg
Salt River Project Agricultural Improvement and Power District
Unit "B" Irrigation and Drainage District
Wellton-Mohawk Irrigation and Drainage District
Yuma County Water Users' Association
Yuma Irrigation District
Yuma Mesa Irrigation and Drainage District

Other Interested Parties Participant Group

QuadState Local Governments Authority
Desert Wildlife Unlimited

California Participant Group

California Department of Fish and Wildlife
City of Needles
Coachella Valley Water District
Colorado River Board of California
Bard Water District
Imperial Irrigation District
Los Angeles Department of Water and Power
Palo Verde Irrigation District
San Diego County Water Authority
Southern California Edison Company
Southern California Public Power Authority
The Metropolitan Water District of Southern California

Nevada Participant Group

Colorado River Commission of Nevada
Nevada Department of Wildlife
Southern Nevada Water Authority
Colorado River Commission Power Users
Basic Water Company

Native American Participant Group

Hualapai Tribe
Colorado River Indian Tribes
Chemehuevi Indian Tribe

Conservation Participant Group

Ducks Unlimited
Lower Colorado River RC&D Area, Inc.
The Nature Conservancy

Lower Colorado River Multi-Species Conservation Program

2019 Updates to Yuma Clapper Rail (*Rallus longirostris yumanensis* Dickey) (CLRA) Basic Conceptual Ecological Model for the Lower Colorado River

Prepared by:

David W. Mehlman, Ph.D., George D. Dickinson, Ph.D., and Robert Unnasch, Ph.D.

Sound Science, LLC

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Basin
Boulder City, Nevada
http://www.lcrmscp.gov

July 2020

Mehlman, D.W., G.D. Dickinson, and R. Unnasch. 2020. 2019 Updates to Yuma Clapper Rail (*Rallus longirostris yumanensis* Dickey) (CLRA) Basic Conceptual Ecological Model for the Lower Colorado River. Submitted to the Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada, by Sound Science, LLC, Boise, Idaho, under contract No. R16PC000028.

ACRONYMS AND ABBREVIATIONS

AZGFD	Arizona Game and Fish Department
CAP	critical biological activity or process
CEM	conceptual ecological model
CF	controlling factor
CLRA	Yuma clapper rail (*Rallus longirostris yumanensis* Dickey or *R. obsoletus yumanensis*)
ha	hectare(s)
HE	habitat element
Imperial NWR	Imperial National Wildlife Refuge
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LSO	life-stage outcome
Reclamation	Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service

Symbols

>	greater than
≥	greater than or equal to
<	less than
%	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.

CONTENTS

Page

Foreword ..... **v**

Updates to Chapter 1 – Introduction **1-1**
Update to Yuma Clapper Rail Reproductive Ecology 1-1
Conceptual Ecological Model Purposes 1-2
Conceptual Ecological Model Structure for the CLRA 1-2

Updates to Chapter 2 – CLRA Life-Stage Model **2-1**
Update to Introduction to the CLRA Life Cycle 2-1
Update to CLRA Life Stage 1 – Eggs/Nestlings 2-2
Update to CLRA Life Stage 2 – Juveniles 2-2
Update to CLRA Life Stage 3 – Breeding Adults 2-3
Life Stage Model Summary 2-3

Updates to Chapter 3 – Critical Biological Activities and Processes **3-1**
Chemical Stress 3-2
Disease 3-2
Eating 3-2
Foraging 3-3
Molting 3-3
Nest Attendance 3-3
Nest Predation 3-4
Nest Site Selection 3-4
Predation 3-4

Updates to Chapter 4 – Habitat Elements **4-1**
Anthropogenic Disturbance 4-2
Brood/Litter Size 4-2
Food Availability 4-3
Genetic Diversity 4-3
Infectious Agents 4-4
Local Hydrology 4-4
Matrix Community 4-5
Nest Predators 4-5
Parental Care 4-5
Patch Size 4-6
Predators 4-6
Residual Vegetation Density 4-6
Site Topography 4-7
Vegetation Community Type 4-7
Vegetation Density 4-7

Page

Updates to Chapter 5 – Controlling Factors 5-1
Fire Management 5-2
Grazing 5-2
Habitat Management and Restoration 5-2
Mechanical Soil Disturbance 5-3
Pesticide Application 5-4
Water Storage-Delivery System Design and Operation 5-5

Updates to Chapter 6 – Conceptual Ecological Model by Life Stage 6-1
New Links with Controlling Factors as Causal Agents 6-1
Deleted Links with Controlling Factors as Causal Agents 6-2
Updated Links with Controlling Factors as Causal Agents 6-2
New Links with Habitat Elements as Causal Agents 6-3
Deleted Links with Habitat Elements as Causal Agents 6-3
Updated Links with Habitat Elements as Causal Agents 6-5
New Links with Critical Activities/Processes as Causal Agents 6-5
Deleted Links with Critical Activities/Processes as Causal Agents 6-5
Updated Links with Critical Activities/Processes as Causal Agents 6-5
New Links with Life-Stage Outcomes as Causal Agents 6-5

Literature Cited in This Update L-1

Acknowledgments A-1

Tables

Table Page

1 (Revision of original table 1) CLRA life stages and life-stage outcomes in the LCR ecosystem 2-4
2 (Revision of original table 2) Critical biological activities and processes by life stage 3-1
3 (Revision of original table 3) Habitat elements directly affecting critical biological activities or processes 4-1
4 (Revision of original table 4) Habitat elements directly affected by controlling factors 5-1
5 Summary of standardization of terms 6-6

Figures

Figure Page

1 (Revision of original figure 1) Proposed CLRA life history model. 2-4

Attachments

Attachment

1 Yuma Clapper Rail (*Rallus longirostris yumanensis* Dickey) (CLRA) Habitat Data

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 Yuma clapper rail (*Rallus longirostris yumanensis* Dickey) (CLRA) (Marty and Unnasch 2015). This update incorporates information reported in publications and presentations at professional meetings since the completion of the original CLRA 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 these were not updated.

The updates reported in the present report change the CLRA 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 it 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. Two controlling factors were added for consistency with other CEMs and species with similar habitat management. These major changes have created numerous edits and adjustments throughout the CEM text and workbook.

The present report also provides a list of all literature cited in the updates to chapters 1–6. In addition, this update provides a list of all changes made to the names 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 CLRA. These questions may or may not reflect the current or future goals of 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, and an additional paragraph is added as follows:

The most widely used sources of information for the Yuma clapper rail (*Rallus longirostris yumanensis* Dickey) (CLRA) conceptual ecological model (CEM) are Bureau of Reclamation (Reclamation) (2008), DUDEK and ICF (2012), Eddleman (1989), Eddleman and Conway (2020), Nadeau et al. (2011), Rush et al. (2020), and the U.S. Fish and Wildlife Service (USFWS) (2010). These publications summarize and cite large bodies of earlier studies. Where appropriate and accessible, those earlier studies are directly cited. The 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 Region 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.

Taxonomic revisions to the species in the clapper/king rail complex of species since the publication of the original CEM have led to the current treatment of the Yuma clapper rail as a subspecies of the Ridgway's rail (*R. obsoletus*); the scientific name *R. longirostris* now refers narrowly to the mangrove rail of South America, and the clapper rail now has the name *R. crepitans* (Chesser et al. 2014; Eddleman and Conway 2020; Maley and Brumfield 2013; Rush et al. 2020; USFWS 2017). However, since this document is an addendum to the original model, the use of the original species name in the title of this update is retained for consistency and because many documents continue to refer to CLRA by its original scientific name of *R. longirostris yumanensis* even though it is now formally called Yuma Ridgway's rail (*R. obsoletus yumanensis*).

UPDATE TO YUMA CLAPPER RAIL REPRODUCTIVE ECOLOGY

CLRA usually begin breeding activities in March or early April, although males can begin calling as early as February (Eddleman and Conway 2020). Nests are constructed on mud hummocks, in small shrubs, or in dense vegetation just above the water (Eddleman 1989; Reclamation 2008). CLRA lay an average of six to eight eggs (Eddleman 1989), with incubation lasting 23–28 days. Both sexes participate in incubating and brood rearing; however, the females typically incubate during the day, whereas the males attend to the nest during the night (Eddleman 1989).

CLRA eggs hatch asynchronously and the young are semiprecocial, able to join their parents on foraging trips within 2 days of hatching (Eddleman and Conway 2020; Hunter et al. 1991). Parents and young remain together as a family group for up to 30 days, with the parents still providing some care. The young fledge 35–42 days after hatching (Arizona Game and Fish Department [AZGFD] 2007) and do not associate with the family group thereafter (Eddleman and Conway 2020).

Optimal CLRA breeding habitat includes a mosaic of tall, emergent vegetation; shallow open water areas; and open dry ground (slightly higher than the water level) for foraging and movement and a band of riparian vegetation along the fringes of the marsh that provides cover and buffer areas that may be used seasonally (USFWS 2010). Predicted rail abundance is correlated with marsh vegetation seasonality (the amount of change in vegetation) between one year and the next and negatively correlated with 5-year accumulated vegetation moisture (Harrity 2019). This is potentially attributable to the steady accumulation of dense marsh vegetation, decadent vegetation, phragmites (*Phragmites australis*), and woody vegetation with time; all of these degrade CLRA habitat quality. Harrity (2019) also finds that CLRA abundance is correlated with shallow pools of open water, mudflats, and moderate vegetation densities.

Primary food items taken by CLRA include crayfish (*Procambarus clarkii* and *Orconectes virilis*), fishes, larval amphibians, clams (Bivalvia), and other aquatic invertebrates (DUDEK and ICF 2012; Reclamation 2008; USFWS 2010). The abundance and condition of the food supply affects adult health as well as the growth and development of the young during the nest and juvenile stages.

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 THE CLRA

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

Updates to Chapter 2 – CLRA Life-Stage Model

This update standardizes the names of CLRA life stages by switching to the plural noun form for each name for consistency with the other LCR MSCP conceptual ecological model updates. The names of the original life-stage outcomes are standardized as follows: (1) Survivors changes to Survival for all four life stages and (2) Offspring and Reproduction change to Fertility; the 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 INTRODUCTION TO THE CLRA LIFE CYCLE

CLRA are one of six subspecies of Ridgway's rail (Eddleman and Conway 2020). Significant populations of CLRA are found within the LCR MSCP boundaries in Reaches 3 and 6 (Reclamation 2008). Since 2008, CLRA have been detected in 2013, 2014, 2015, 2016, 2017, and 2018 in Topock Gorge and other locations within Reach 3 (Kahl, Jr. 2015b, 2016, 2018b, 2019) and in the following lower Colorado River (LCR) conservation areas: Beal Lake (Reach 3) in 2014, 2015, 2016, 2017, and 2018; Big Bend (Reach 3) in 2015; Hart Mine Marsh (Reach 4) in 2013, 2014, 2015, 2016, 2017, and 2018; Imperial Ponds (Reach 5) in 2013, 2014, 2015, 2016, and 2017; Laguna Division (Reach 6) in 2017 and 2018, and Yuma East Wetlands (Reach 6) in 2014, 2015, 2016, 2017, and 2018 (Kahl, Jr. 2015a, 2018a; Ronning and Kahl, Jr. 2017, 2018). CLRA are secretive birds, but males can be heard calling at the beginning of the breeding season in February, with pair bonding following soon thereafter (Eddleman and Conway 2020).

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

Recent studies clearly document seasonal migration for at least some CLRA occurring in the LCR (Harrity and Conway 2018, 2019a), contrasting with previous speculation that the taxon was sedentary (Eddleman 1989). Harrity and Conway (2019a) document that at least 42.9% of adult and 21.4% of juvenile CLRA studied conducted migratory movements in fall and found two U.S. breeding rails that migrated ≥ 900 kilometers to wintering grounds in Mexico and returned the following year. However, the proportion of individuals at different sites in the LCR that are migratory varies, with the proportion of rails

migrating ranging from 100% at the Cibola National Wildlife Refuge and 83.3% at the Havasu National Wildlife Refuge to 30.0% at the Imperial National Wildlife Refuge (Imperial NWR) and none at the Sonny Bono Salton Sea National Wildlife Refuge (Harrity and Conway 2019a). The LCR MSCP is mainly responsible for management on the breeding grounds; therefore, the focus is on life stages occurring within LCR MSCP lands: eggs/nestlings, juveniles, and breeding adults. Reclamation and other Federal and State agencies collectively manage 70.5% of predicted wetlands with high suitability for CLRA (Harrity 2019).

Interestingly, the movement corridors for migrating CLRA were not associated with water or river corridors; CLRA were found to have crossed desert uplands and open water within 160 kilometers of the coast of the Gulf of California (Harrity and Conway 2019a). Similarly, the use of stopover habitat by migrating rails was also very broad, including desert scrub, irrigation ditches, agricultural fields, golf courses, and irrigation impoundments (Harrity and Conway 2019a).

UPDATE TO CLRA LIFE STAGE 1 – EGGS/ NESTLINGS

We consider the eggs/nestlings stage to be the first in the life cycle of CLRA. It begins when the egg is laid and ends either when the young fledge or the nest fails. Nesting begins in March, and incubation lasts around 23–28 days, with males incubating at night and females during the day (Eddleman and Conway 2020). Hatching success is high, but so is juvenile mortality (Eddleman 1989). Within 2 days of hatching, chicks accompany adults on foraging trips (Hunter et al. 1991). Family groups of rails remain together for up to 30 days after hatching, with chicks becoming independent of their parents at 35–42 days post-hatching (Eddleman and Conway 2020). The life-stage outcome from the eggs/nestlings stage is the survival of eggs and associated chicks until they become independent. It is important to note that the outcome of the eggs/nestlings stage is inherently tied to the behavior and physical condition of the parents.

UPDATE TO CLRA 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 CLRA is unknown but is presumed to be around 1 year of age (Eddleman 1989). 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 CLRA in these life stages interact with the

environment were potentially significantly different enough to warrant the split. An analysis of band recovery data for clapper rails, both hunted birds and band recoveries, suggested a mean annual juvenile survival rate of 0.368 (standard error = 0.070) (Arnold et al. 2016).

UPDATE TO CLRA LIFE STAGE 3 – BREEDING ADULTS

This life stage begins when the rail reaches sexual maturity and ends when it stops reproducing. It is estimated that adult CLRA reach sexual maturity around 1 year of age. Breeding begins in March with the establishment of breeding territories (Eddleman 1989). Both males and females defend the territories. Nesting occurs from March through May but varies based on seasonal rainfall patterns (USFWS 2010). A single clutch of three to seven eggs is laid unless the clutch is lost, then the rails will renest up to five times in a season (AZGFD 2007; Eddleman and Conway 2020).

The life-stage outcomes for breeding adults are survival and fertility—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 eggs/nestlings 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.

Little data is available on survivorship of CLRA. An analysis of band recovery data, both hunted birds and band recoveries, suggested a mean annual adult survival rate of 0.500 (standard error = 0.025) and that annual fecundity would need to average 1.41 (standard deviation = 0.31) young/adult to ensure a stable population (Arnold et al. 2016). Annual survival of radio-tagged CLRA in Arizona ranged from 49 to 67%, with most mortality occurring in fall and winter (Eddleman 1989). In southern California populations of the light-footed Ridgway's rail (*R. obsoletus levipes*), average annual survival was 45.4% (95% confidence interval; 36.9–54.3) (Hoffman 2001 *in* Eddleman and Conway 2020).

LIFE STAGE MODEL SUMMARY

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

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

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

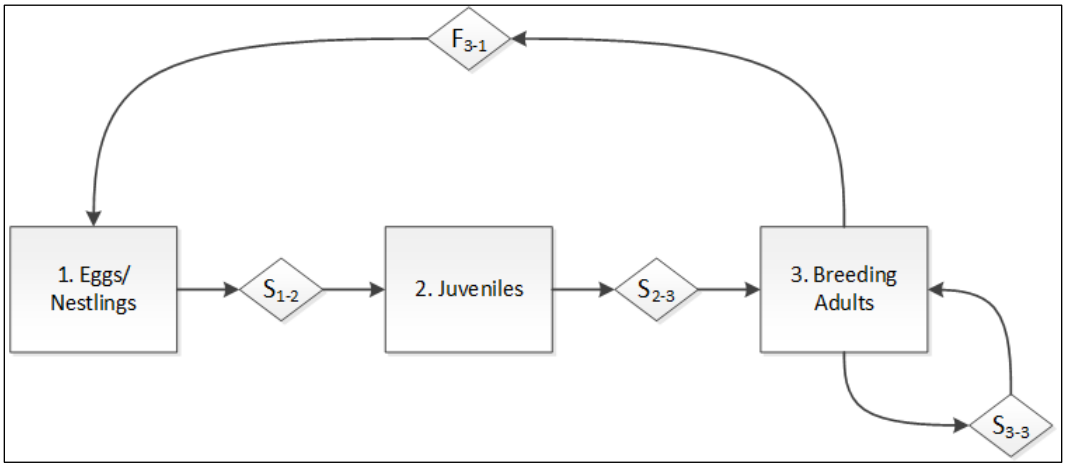

Figure 1.—(Revision of original figure 1) Proposed CLRA life history model. Squares indicate life stages, and diamonds indicate life-stage outcomes. S_{1-2} = Survival, Eggs/Nestlings; S_{2-3} = Survival, Juveniles; S_{3-3} = Survival, Breeding Adults; and F_{3-1} = Fertility, Breeding Adults.

Updates to Chapter 3 – Critical Biological Activities and Processes

This update identifies nine critical biological activities or processes that affect one or more CLRA life stages. The original CLRA 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 activities or processes in this update and their distribution across life stages and indicates which are new to this update or renamed from the original CLRA 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:

CLRA in every life stage are vulnerable to stress and mortality due to exposure to harmful chemicals, including selenium and pesticides/herbicides. Environmental contaminants are believed to have potential negative impacts on rail populations due to the bioaccumulation of these chemicals (Ackerman et al. 2012; Eagles-Smith et al. 2016; Lonzarich et al. 1992; Rusk 1991; Tsao et al. 2009). It was recognized as early as 1989 that heavy metals were a potential threat to rail survival, with high levels of selenium detected in adults, their eggs, and crayfish, CLRA's primary food source (Eddleman 1989). 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 more recently by Schwarzbach et al. (2006), along with the demonstration that contaminants can be passed from parents to eggs (Ackerman et al. 2016). Pesticide/herbicide residue may also have negative impacts on CLRA survival (DUDEK and ICF 2012).

DISEASE

The definition of this critical biological activity or process remains unchanged. No new information was located on disease patterns or consequences among CLRA 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 chicks must eat to stay alive and develop, but they do not actively forage within their environment in the same way as juveniles and breeding adults. A nestling'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:

CLRA forage in marsh habitat predominantly on crayfish but also small fishes, tadpoles, clams, and other aquatic invertebrates (Anderson and Ohmart 1985; Eddleman 1989; Eddleman and Conway 2020). 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, and the discussion 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). CLRA chicks molt from natal down into juvenal plumage in about a month (USFWS 2010) from May to July on the breeding grounds (Eddleman and Conway 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 in July to November on the breeding grounds. After breeding, adults undergo a complete pre-basic molt on the breeding grounds from early July to September (Eddleman and Conway 2020; Harrity and Conway 2017). During this molt, they lose their wing and tail feathers simultaneously and are flightless for 3 to 4 weeks (Eddleman and Conway 2020; Pyle 2008). Pre-alternate molts are not known to occur in CLRA with any certainty, though they may occur to a limited extent in January to February on the wintering grounds (Eddleman and Conway 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 the young (Eddleman 1989; Eddleman and Conway 2020). Breeding adults attend the nest, and this affects the survival of the nestlings.

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 CLRA in the eggs/nestlings life stage, and it obviously affects survival. Norway rats (*Rattus norvegicus*), red foxes (*Vulpes vulpes*), marsh wrens (*Cistothorus palustris*), ravens (*Corvus* sp.), coyotes (*Canis latrans*), raccoons (*Procyon lotor*), and skunks (*Mephitis* sp.) are common predators of CLRA eggs and chicks (AZGFD 2007; Eddleman and Conway 2020).

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 food availability, hydrology, predator types and densities, vegetation characteristics, and other factors (USFWS 2010). The availability of high ground is also a factor in nest site selection of CLRA (Bennett and Ohmart 1978; Eddleman 1989; Eddleman and Conway 2020; Smith 1975). Though adult rails can swim, chicks can drown when their downy plumage gets wet. Various aspects of local hydrology are critical for nest site selection of CLRA, 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 and ICF 2012; Nadeau et al. 2011).

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 CLRA in the juveniles and breeding adults life stages, and it obviously affects survival. CLRA are subject to predation by coyotes, dogs (*Canis lupus*), cats (*Felis catus*), raccoons, ravens, great blue herons (*Ardea herodias*), great horned owls (*Bubo virginianus*) and other owl species, northern harriers (*Circus hudsonius*), and other hawk species (Eddleman 1989; Eddleman and Conway 2020). Factors affecting adult mortality may include movement of predators into marsh habitat, increases in wintering raptors, and changes in CLRA habitat use due to changing water levels (Eddleman 1989).

Updates to Chapter 4 – Habitat Elements

This update identifies 15 habitat elements that affect 1 or more critical biological activity or process across 1 or more CLRA life stages. The original CLRA 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; adds one new habitat element (Nest Predators) by separating it from 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; splits one habitat element (Genetic Diversity and Infectious Agents) into two separate elements; deletes one habitat element (Aquatic Faunal Composition) by merging it with Food Availability; and updates the discussion of 10 habitat elements. Table 3 lists the 15 habitat elements in this update, indicates the critical biological activities or processes they *directly* affect across all CLRA life stages, and indicates which habitat elements are new to this update or renamed from the original CLRA conceptual ecological model.

Table 3.—(Revision of original table 3) Habitat elements directly affecting critical biological activities or 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	
Matrix community	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
Residual vegetation density				X				X	
Site topography								X	
Vegetation community type (*replaces plant species composition*)				X				X	
Vegetation density							X	X	

ANTHROPOGENIC DISTURBANCE

The discussion of 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 CLRA habitat. These human disturbances may be a cause for bird 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. Noise from human talking, radios, and vehicles may disturb rails, though it is unknown what level of noise is necessary to cause habitat abandonment. Artificial lights and other factors associated with human facilities development may impact behavior patterns, increase the risk of night predators, and affect nest site selection (USFWS 2010). However, certain areas of known rail use are subject to background disturbance from traffic, boats, lights, or trains, suggesting that some level of acclimatization is possible (C. Ronning, J. Kahl, Jr., and C. Dodge 2019, personal communications).

High-intensity development was negatively associated with CLRA occupancy across its range (Glisson et al. 2017), although the same study found positive associations between CLRA occupancy and agriculture or low-intensity development. The latter finding may be due to either subsurface drainage from agricultural fields benefiting adjacent wetland habitats used by CLRA or increasing the invertebrate prey base in adjacent wetlands (Glisson et al. 2017).

Casazza et al. (2016) studied predation of the related California Ridgway's rail (*R. obsoletus obsoletus*) and suggested that human structures in or near rail habitat could contribute to avian predation of rails and, therefore, that reducing them could be a method of lowering rail predation. Similarly, light pollution at night associated with anthropogenic disturbance may contribute to elevated predation of rails, especially by mammals (Casazza et al. 2016).

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 CLRA in the Lower Colorado River Valley or elsewhere.

FOOD AVAILABILITY

This habitat element now includes the former habitat element of Aquatic Faunal Composition, and it 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 CLRA will encounter during the eggs/nestlings, juveniles, and breeding adults life 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 life stages. Chicks rely on their parents for nutrition for a very brief period before they begin to forage independently.

The composition of the aquatic faunal community directly affects CLRA prey abundance and foraging activity. The diet of CLRA is dominated by crayfish, with small fishes, tadpoles, clams, and other aquatic invertebrates also consumed (Bennett and Ohmart 1978; Eddleman and Conway 2020; USFWS 2010). CLRA have been found to shift their habitat use depending on the seasonal availability of crayfish (Eddleman 1989). The composition of the aquatic faunal community (and thus CLRA prey abundance) is influenced by the structure and composition of vegetation. A primary prey source, crayfish, are found in dense cattail (*Typha* sp.) and bulrush (Cyperaceae) habitat (Bennett and Ohmart 1978).

GENETIC DIVERSITY

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

Full name: **The genetic diversity of CLRA individuals**. The genetic diversity component of 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 CLRA and other marsh birds is of particular concern as demonstrated by the genetic structuring of California Ridgway's rail populations

in the salt marsh fragments of the San Francisco Bay region (Wood et al. 2017). However, the Fleischer et al. (1995) study of minisatellite DNA variability in Yuma and light-footed Ridgway's rail populations in California found CLRA genetic variability to be about what was expected for most bird populations; its variability was not particularly low.

INFECTIOUS AGENTS

The habitat element of Genetic Diversity and Infectious Agents has been separated into two distinct habitat elements, and it 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 CLRA are likely to encounter during each life stage. In general, there is little to no information on diseases or parasites of CLRA (Eddleman and Conway 2020). However, Harrity and Conway (2019a, 2019b) document a severe trombiculid mite infestation in CLRA throughout their range. Infestation varied, with 48 of 52 birds (92%) at the Imperial NWR, but only 11% of birds at the Cibola National Wildlife Refuge, and no birds at either the Sonny Bono Salton Sea National Wildlife Refuge or at the lower Gila River. This may represent a potential emerging threat to CLRA (Harrity and Conway 2019a).

LOCAL HYDROLOGY

The discussion of 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 as well as the 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 CLRA habitat quality because they affect other aspects of habitat such as vegetation structure and abundance of prey. Various aspects of local hydrology are critical for nest site selection, 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; DUDEK and ICF 2012; Nadeau and Conway 2015; Nadeau et al. 2011; Richmond et al. 2010). Harrity (2019) found that CLRA abundance was correlated with shallow pools of open water, mudflats, and moderate vegetation densities.

CLRA 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). More open, slow-moving water areas associated with rivers were negatively associated with CLRA occupancy in range-wide models (Glisson et al. 2017). Ongoing research to examine the effects of water level fluctuation in Topock Gorge on CLRA occupancy suggests that fluctuations of 0.41–1.6 meters do not affect the presence of CLRA (Dodge and Rudd 2017).

MATRIX COMMUNITY

The definition of this habitat element remains unchanged. No new information was located on the matrix community among CLRA 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 CLRA during the eggs/nestlings life stage. The variables of this element include the species and size of the fauna that prey on CLRA during the eggs/nestlings life stage, the density and spatial distribution of these fauna in the habitat used by CLRA, 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, and it 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 up to 6 weeks after fledging, although the chicks are semiprecocial (Eddleman and Conway 2020). Parental care is provided by one or both parents and includes providing shelter and warmth, finding and 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

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

PREDATORS

This habitat element replaces the original, Predator Density, for clarity and consistency among models, and it is updated as follows:

Full name: **The abundance and distribution of species that depredate CLRA during the juveniles and breeding adults 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 CLRA during the juveniles and breeding adults life stages. The variables of this element include the species and size of the fauna that prey on CLRA during different life stages, the density and spatial distribution of these fauna in the habitat used by CLRA, 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 discussion of this habitat element is updated as follows:

Full name: **The density of senescent foliage surrounding the nest**. Some matting of previous years' vegetation is necessary for CLRA movement, especially across deep-water habitat (Eddleman 1989). However, CLRA use of habitat declines as levels of residual vegetation increase (Conway and Eddelman 2000;Conway et al. 2010; Eddleman and Conway 2020).

SITE TOPOGRAPHY

The discussion of this habitat element is updated as follows:

Full name: **The topographic relief of the land surrounding the nest**. The availability of high ground is a factor in nest site selection of CLRA (Bennett and Ohmart 1978; Smith 1975). Though adult rails can swim, chicks can drown when their downy plumage gets wet. CLRA may select areas with higher ground for their nests, and these may include features such as edges of tidal sloughs, jetties, and levees (Anderson and Ohmart 1985; Eddleman 1989; Eddleman and Conway 2020).

VEGETATION COMMUNITY TYPE

This habitat element replaces the original, Plant Species Composition, for consistency with other CEMs, and it 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 CLRA are active. The plant species composition preferred by nesting CLRA has been considered in some studies as immaterial as long as the hydrologic characteristics were adequate, although the two are highly correlated. However, many studies have considered marsh species, including cattails and bulrush, as providing optimal habitat, while phragmites is generally considered poor quality habitat (Eddleman 1989). Generally, low stem densities and residual vegetation coverage are considered suitable habitat for CLRA (Conway et al. 1993). In a study of CLRA habitat use of restored habitat in the Imperial NWR, CLRA were more likely to be found in areas with lower densities of river bulrush (*Schoenoplectus robustus*) and moderate densities of phragmites and southern cattails (*Typha domingensis*) (Nadeau et al. 2011).

VEGETATION DENSITY

The discussion of this habitat element is updated as follows:

Full name: **The density of foliage surrounding the nest**. This element refers to the percent cover of vegetation in the vicinity of the CLRA nest site. The presence of CLRA has been correlated with higher levels of vegetation density, especially cattails and bulrush (Anderson and Ohmart 1985). Dense vegetation around the nest may provide camouflage from nest predators, although heterogeneity in vegetation cover within a given patch or landscape is also desirable. Optimum CLRA habitat includes a mosaic of tall, emergent vegetation;

shallow (less than 30 centimeters deep) open water areas; open dry ground (slightly higher than the water level) between water; vegetation; marsh edge for foraging and movement; and a band of riparian vegetation on the higher ground along the fringes of the marsh that provides cover and buffer areas that may be used seasonally (USFWS 2010). Nadeau et al. (2011) found the probability of CLRA occupancy in restored marsh habitat to be positively correlated with low densities of river bulrush and moderate densities of phragmites and southern cattails.

Updates to Chapter 5 – Controlling Factors

This update identifies eight controlling factors that affect one or more habitat elements and/or critical biological activities or processes across the three CLRA life stages. The original CLRA conceptual ecological model (Marty and Unnasch 2015) identified six controlling factors. This update adds two controlling factors (Grazing and 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 three 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 CLRA 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 (*new*)**	**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		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

The discussion of this controlling factor is updated as follows:

This factor addresses any fire management (whether prescribed fire or fire suppression) along the LCR that could affect CLRA or their habitat. Effects may include creation of habitat that supports or excludes CLRA, a reduction in the food supply of invertebrates, or support of species that pose threats to CLRA 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 CLRA by removing decadent vegetation and encouraging growth of early successional emergent vegetation (Conway et al. 2010; Gomez Sapiens 2014). Harrity (2019) documents a steady increase in predicted CLRA abundance in three units of the Imperial NWR in the years immediately after a prescribed fire.

Climate change is also projected to affect fire frequency along the LCR (USFWS 2013).

GRAZING

This controlling factor is added for consistency with other CEMs.

This factor addresses grazing by wild, domesticated, and feral animals in marsh habitat along the LCR that could affect CLRA or their habitat. Grazing alters the vegetation structure through loss of emergent cover via trampling and direct removal (Butler et al. 2014). Currently, grazing is minimal in LCR MSCP marsh habitat. None of the available reviews of threats to CLRA or its habitat indicate that grazing is a threat or management issue (e.g., DUDEK 2014; Eddleman and Conway 2020; USFWS 2010).

HABITAT MANAGEMENT AND RESTORATION

This controlling factor replaces the original, Habitat Restoration, and it is updated as follows:

This factor addresses activities to restore the 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 CLRA occupancy in restored wetlands was positively correlated with early successional southern cattails and phragmites, negatively correlated with river bulrush, and highest with water depths between 0 and 65 millimeters (Nadeau et al. 2011).

For example, Trathnigg and Phillips (2015, 2017) 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, including CLRA in marsh restoration sites. Restored sites had significantly higher percent herb cover and significantly lower percent open water than control sites; percent shrub cover was higher in control sites than restoration sites but not significantly so (Trathnigg and Phillips 2015).

The predictive habitat suitability maps developed by Harrity (2019; figure 15) could be used to target habitat management, restoration, or protection efforts in the LCR, particularly those sites with predicted high abundance in at least some years. Interestingly, he found that 70.5% of predicted wetlands with high suitability are in existing national wildlife refuges or wildlife areas.

MECHANICAL SOIL DISTURBANCE

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

NUISANCE SPECIES INTRODUCTION AND MANAGEMENT

The discussion of 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 CLRA survival and reproduction. The nuisance species may infect, prey on, compete with, or present alternative food resources for CLRA during one or more life stages; cause other alterations to the wetland food web that affect CLRA; or affect physical habitat features such as vegetation structure and cover.

Harrity (2019) suggests that phragmites encroachment into wetlands inhabited by CLRA reduces habitat quality both by converting stands into dense monotypes of phragmites and by increasing winter greenness (since phragmites do not turn brown and grow dormant), an attribute which is detectable by remote sensing imagery.

ON-SITE WATER MANAGEMENT

This controlling factor is added to the original 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 CLRA habitat. In particular, this addresses water management for ponds and marshes maintained by the LCR and includes areas such as the Beal Lake, Big Bend, Hart Mine Marsh, Imperial Ponds, and Laguna Division Conservation Areas, and Yuma East Wetlands, most of which consistently support CLRA (Kahl, Jr. 2015a, 2018a; Ronning and Kahl, Jr. 2017, 2018). CLRA rely on certain minimum and maximum water levels during the breeding season (Nadeau et al. 2011), and their abundance at a site will vary over time, depending on water levels.

On-site water management in the LCR may include actions to reduce or terminate water applications at a site, for example 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 CLRA.

PESTICIDE APPLICATION

This controlling factor replaces the original, Pesticide/Herbicide Application, and it is updated as follows:

This factor addresses pesticide applications that may occur on or adjacent to CLRA habitat in the LCR region. The use of pesticides was listed as a potential threat to CLRA (USFWS 2010). Effects may include pollution of runoff into wetland habitats that are toxic to prey of CLRA and a reduced invertebrate food supply.

WATER STORAGE-DELIVERY SYSTEM DESIGN AND OPERATION

The definition of this controlling factor remains unchanged. No new information was located on water storage-delivery system design and operation among CLRA in the Lower Colorado River Valley or elsewhere.

Updates to Chapter 6 – Conceptual Ecological Model by Life Stage

The following sections identify all changes made to the CLRA 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, below). 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 to ensure compatibility with other CEMs. *Applies to all life stages*.

- Grazing to Nuisance Species Introduction and Management (CF): This link was added to ensure compatibility with other CEMs. Grazing is known to affect nuisance species presence in many habitats but is not suspected of being a threat or management issue for CLRA. The link is hypothesized to be positive and unidirectional with proposed low intensity, spatial, and temporal scale; medium predictability; and medium understanding. *Applies to all life stages*.

- Grazing to Residual Vegetation Density (HE): This new link was added to ensure compatibility with other CEMs. Grazing is known to affect residual vegetation density in many habitats but is not suspected of being a threat or management issue for CLRA. The link is hypothesized to be complex and unidirectional with proposed low intensity, spatial, and temporal scale; medium predictability; and low understanding. *Applies to all life stages*.

- Grazing to Vegetation Community Type (HE): This new link was added to ensure compatibility with other CEMs. Grazing is known to affect plant species composition in many habitats but is not suspected of being a threat or management issue for CLRA. The link is hypothesized to be complex and unidirectional with proposed low intensity, spatial, and temporal scale; medium predictability; and low understanding. *Applies to all life stages*.

- Grazing to Vegetation Density (HE): This new link was added to ensure compatibility with other CEMs. Grazing is known to affect vegetation density in many habitats but is not suspected of being a threat or management issue for CLRA. The link is hypothesized to be complex and unidirectional with proposed low intensity, spatial, and temporal scale; medium predictability; and low understanding. *Applies to all life stages*.

- Mechanical Soil Disturbance to Anthropogenic Disturbance (HE): This link was added to ensure compatibility with other CEMs. *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

No change.

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*.

- Residual Vegetation Density to Nest Site Selection (CAP): This new link was added due to new information. Increased residual vegetation density is known to be associated with lower CLRA occupancy and should, therefore, lead to lower nest site selection. The link is hypothesized to be negative with no or an unknown threshold and unidirectional with proposed low intensity and medium spatial and temporal scale; medium predictability; and medium understanding. *Applies to the breeding adults life stage*.

DELETED LINKS WITH HABITAT ELEMENTS AS CAUSAL AGENTS

- Anthropogenic Disturbance to Foraging (CAP): This link was deleted because the foraging critical activity or 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 or 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 or 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.

Table 5.—Summary of standardization of terms
(Blue indicates new or revised items; orange indicates replaced items.)

CLRA conceptual ecological model updated terms, 2019	CLRA 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 *(renamed)*	Aquatic Faunal Composition, Food Availability
Genetic Diversity	
Infectious Agents	
(eliminated; see Genetic Diversity, see Infectious Agents)	Genetic Diversity and Infectious Agents
Local Hydrology	Local Hydrology
Matrix Community	Matrix Community
Nest Predators *(new)*	
Parental Care *(renamed)*	Parental Nest Attendance
Patch Size	Patch Size
Predators *(renamed)*	Predator Density
Residual Vegetation Density	Residual Vegetation Density
Site Topography	Site Topography
Vegetation Community Type *(renamed)*	Plant Species Composition
Vegetation Density	Vegetation Density
Controlling factors	
Fire Management	Fire Management
Grazing *(new)*	
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

LITERATURE CITED IN THIS UPDATE

Ackerman, J.T., C.T. Overton, M.L. Casazza, J.Y. Takekawa, C.A. Eagles-Smith, R.A. Keister, and M.P. Herzog. 2012. Does mercury contamination reduce body condition of endangered California clapper rails? Environmental Pollution 162:439–448. https://doi.org/10.1016/j.envpol.2011.12.004

Ackerman, J.T., C.A. Eagles-Smith, M.P. Herzog, and C.A. Hartman. 2016. Maternal transfer of contaminants in birds: mercury and selenium concentrations in parents and their eggs. Environmental Pollution 210:145–154.

Anderson, B.W. and R.D. Ohmart. 1985. Habitat use by clapper rails in the Lower Colorado River Valley. The Condor 87:116–126.

Arizona Game and Fish Department (AZGFD). 2007. Element Code ABNME0501A [for the Yuma Clapper Rail]. Animal Abstract. Heritage Data Management System. Arizona Game and Fish Department, Phoenix, Arizona.

Arnold, T.W., C.N. de Sobrino, and H.M. Specht. 2016. Annual survival rates of migratory shore and upland game birds. Wildlife Society Bulletin 40(3):470–476.

AZGFD (see Arizona Game and Fish Department).

Bennett, W.W. and R.D. Ohmart. 1978. Habitat Requirements and Population Characteristics of the Clapper Rail (*Rallus longirostris yumanensis*) in the Imperial Valley of California. University of California, Lawrence Livermore Laboratory, Livermore, California. 55 p.

Bureau of Reclamation (Reclamation). 2008. Yuma Clapper Rail (*Rallus longirostris yumanensis*). Pages 8-21 *in* Species Accounts for the Lower Colorado River Multi-Species Conservation Program. Bureau of Reclamation, Boulder City, Nevada. https://www.lcrmscp.gov/reports/2008/c03_species_accounts_2008.pdf

Butler, C.J., J.B. Tibbits, and K. Hucks. 2014. Status of 10 Additional Bird Species of Conservation Concern in U.S. Fish and Wildlife Service Region 6. Report prepared for the U.S. Fish and Wildlife Service, Denver, Colorado.

Casazza, M.L., C.T. Overton, T.D. Bui, J.Y. Takekawa, A.M. Merritt, and J.M. Hull. 2016. Depredation of the California Ridgway's rail: causes and distribution. Proceedings of the 27th Vertebrate Pest Conference, pp. 226–235.

Chesser, R.T., R.C. Banks, C. Cicero, J.L. Dunn, A.W. Kratter, I.J. Lovette, A.G. Navarro-Sigüenza, P.C. Rasmussen, J.V. Remsen, Jr., J.D. Rising, D.F. Stotz, and K. Winker. 2014. Fifty-fifth supplement to the American Ornithologists' Union Check-List of North American Birds. The Auk: Ornithological Advances 131(4):CSi–CSxv. https://doi.org/10.1642/AUK-14-124.1

Conway, C.J. and W.R. Eddleman. 2000. Yuma Clapper Rail. Pages 279–284 *in* R.P. Reading and B. Miller (editors). Endangered Animals: A Reference Guide to Conflicting Issues. Greenwood Press, Westport, Connecticut.

Conway, C.J., W.R. Eddleman, S.H. Anderson, and L.R. Hanebury. 1993. Seasonal changes in Yuma clapper rail vocalization rate and habitat use. Journal of Wildlife Management 57(2):282–290.

Conway, C.J., C.P. Nadeau and L. Piest. 2010. Fire helps restore natural disturbance regime to benefit rare and endangered marsh birds endemic to Colorado River. Ecological Applications 20(7):2024–2035.

Dodge, C. and N. Rudd. 2017. Marsh Bird Water Depth Analysis, 2016 Progress Report. Annual report prepared by the Lower Colorado Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

DUDEK. 2014. Draft Desert Renewable Energy Conservation Plan Baseline Biology Report Species Profile for California Black Rail (*Laterallus jamaicensis coturniculus*). Sacramento, California.

DUDEK and ICF. 2012. Draft Desert Renewable Energy Conservation Plan Baseline Biology Report Species Profile for Yuma Clapper Rail (*Rallus longirostris yumanensis*). Sacramento, California.

Eagles-Smith, C.A., J.G. Wiener, C.S. Eckley, J.J. Willacker, D.C. Evers, M. Marvin-DiPasquale, D. Obrist, J.A. Fleck, G.R. Aiken, J.M. Lepak, A.K. Jackson, J.P. Webster, A.R. Stewart, J.A. Davis, C.N. Alpers, and J.T. Ackerman. 2016. Mercury in western North America: a synthesis of environmental contamination, fluxes, bioaccumulation, and risk to fish and wildlife. Science of the Total Environment 568:1213–1226.

Eddleman, W.R. 1989. Biology of the Yuma Clapper Rail in the Southwestern U.S. and Northwestern Mexico. Final report to the Bureau of Reclamation, Yuma Projects Office, and Fish and Wildlife Service, Region 2, by the Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, Wyoming. 127 p.

Eddleman, W.R. and C.J. Conway. 2020. Ridgway's Rail (*Rallus obsoletus*), version 1.0 *in* P.G. Rodewald (editor). Birds of the World. Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/bow.ridrai1.01

Etterson, M.A., S.N. Ellis-Felege, D. Evers, G. Gauthier, J.A. Grzybowski, B.J. Mattsson, L.R. Nagy, B.J. Olsen, C.M. Peasei, M.P. van der Burg, and A. Potvienk. 2011. Modeling fecundity in birds: conceptual overview, current models and considerations for future developments. Ecological Modeling 222:2178–2190.

Fleischer, R.C., G. Fuller, and D.B. Ledig. 1995. Genetic structure of endangered clapper rails (*Rallus longirostris*) populations in southern California. Conservation Biology 9(5):1234–1243.

Gill, F.B., R.O. Prum, and S.K. Robinson. 2019. Ornithology, Fourth Edition. W.H. Freeman Macmillan Learning, New York, New York. 666 p.

Glisson, W.J., C.J. Conway, C.P. Nadeau, and K.L. Borgmann. 2017. Habitat models to predict wetland bird occupancy influenced by scale, anthropogenic disturbance, and imperfect detection. Ecosphere 8(6): Article e01837.

Gomez Sapiens, M.M. 2014. Linking shorebird and marsh bird habitat use to water management in anthropogenic and natural wetlands in the Colorado River Delta. Ph.D. dissertation. University of Arizona, Tucson, Arizona.

Harrity, E. 2019. Remotely sensed metrics help map range-wide habitat suitability and identify habitat restoration priorities for an endangered marsh bird. M.Sc. thesis. University of Idaho, Moscow, Idaho.

Harrity, E. and C.J. Conway. 2017. Dispersal behavior of Yuma Ridgway's Rails. 2017 Annual Report for Cibola National Wildlife Refuge. Wildlife Research Report #2017-02. Idaho Cooperative Fish and Wildlife Research Unit, Moscow, Idaho.

_____. 2018. Dispersal and Migration Behavior of Yuma Ridgway's Rails, 2018 Annual Report. Wildlife Research Report #2018-1. Idaho Cooperative Fish and Wildlife Research Unit, Moscow, Idaho.

_____. 2019a. Dispersal and Migration Behavior of Yuma Ridgway's Rails, 2019 Annual Report. Wildlife Research Report #2019-01. Idaho Cooperative Fish and Wildlife Research Unit, Moscow, Idaho.

_____. 2019b. Novel ectoparasite infestation on Yuma Ridgway's Rails (*Rallus obsoletus yumanensis*). The Wilson Journal of Ornithology 131(1):139–146.

Howell, S.N.G. 2010. Peterson Reference Guide to Molt in North American Birds. Houghton Mifflin Harcourt, New York, New York.

Hunter, W.C., K.V. Rosenberg, R.D. Ohmart, and B.A. Anderson. 1991. Birds of the Lower Colorado River Valley. University of Arizona Press, Tucson, Arizona.

Jacobson, R.B., M.L. Annis, M.E. Colvin, D.A. James, T.L. Welker, and M.J. Parsley. 2016. Missouri River *Scaphirhynchus albus* (Pallid Sturgeon) Effects Analysis—Integrative Report 2016. Scientific Investigations Report 2016–5064. U.S. Geological Survey, Reston, Virginia.

Kahl, Jr., J. 2015a. Marsh Bird Surveys, Conservation Areas – 2013 Annual Report. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

_____. 2015b. 2013 Marsh Bird Surveys, Topock Gorge. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

_____. 2016. Marsh Bird Surveys in Topock Gorge, 2014 Annual Report. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

_____. 2018a. Marsh Bird Surveys at Conservation Areas, 2018 Annual Report. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

_____. 2018b. Marsh Bird Surveys in Topock Gorge, 2015–2017. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

_____. 2019. Marsh Bird Surveys in Topock Gorge, 2018 Annual Report. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

Lonzarich, D.G., T.E. Harvey, and J.E. Takekawa. 1992. Trace element and organochlorine concentrations in California clapper rail (*Rallus longirostris obsoletus*) eggs. Archives of Environmental Contamination and Toxicology 153(23):147–153.

Maley, J.M. and R.T. Brumfield. 2013. Mitochondrial and next-generation sequence data used to infer phylogenetic relationships and species limits in the clapper/king rail complex. The Condor 115(2):316–329.

Marty, J. and R. Unnasch. 2015. Yuma Clapper Rail (*Rallus longirostris yumanensis* Dickey) (CLRA) Basic Conceptual Ecological Model for the Lower Colorado River. Submitted to the Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada, by Sound Science, LLC, Boise Idaho.

Murphy, D.D. and P.S. Weiland. 2011. The route to best science in implementation of the Endangered Species Act's consultation mandate: the benefits of structured effects analysis. Environmental Management 47(2):161–172.

_____. 2014. Science and structured decision making: fulfilling the promise of adaptive management for imperiled species. Journal of Environmental Studies and Sciences 4(3):200–207.

Nadeau, C.P. and C.J. Conway. 2015. Optimizing water depth for wetland-dependent wildlife could increase wetland restoration success, water efficiency, and water security. Restoration Ecology 23(3):292–300. https://doi.org/10.1111/rec.12180

Nadeau, C.P., C.J. Conway, M.A. Conway, and M. Ogonowski. 2011. Restoration of Managed Marsh Units to Benefit California Black Rails and Other Marsh Birds: An Adaptive Management Approach, Final Report. Wildlife Research Report #2011-01. U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, Tucson, Arizona.

Pyle, P. 2008. Identification Guide to North American Birds, Part II: Anatidae to Alcidae. Slate Creek Press, Point Reyes Station, California.

Reclamation (see Bureau of Reclamation).

Richmond, O.M.W., S.K. Chen, B.B. Risk, J. Tecklin, and S.R. Beissinger. 2010. California black rails depend on irrigation-fed wetlands in the Sierra Nevada foothills. California Agriculture 64(2):85–93. https://doi.org/10.3733/ca.v064n02p85

Ronning, C.J. and J. Kahl, Jr. 2017. Marsh Bird Surveys at Conservation Areas, 2014–2016 Annual Report. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

_____. 2018. Marsh Bird Surveys, Conservation Areas – 2017 Annual Report. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada.

Ronning, C.J., J. Kahl, Jr., and C. Dodge. 2019. Lower Colorado River Multi-Species Conservation Program, Bureau of Reclamation, Boulder City, Nevada. Personal communication.

Rush, S.A., K.F. Gaines, W.R. Eddleman, and C.J. Conway. 2020. Clapper Rail (*Rallus crepitans*), version 1.0 *in* P.G. Rodewald (editor). Birds of the World. Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/bow.clarai11.01

Rusk, M.K. 1991. Selenium Risk to Yuma Clapper Rails and Other Marsh Birds of the Lower Colorado River, Research Report. Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, Arizona. 75 p.

Schwarzbach, S.E., J.D. Albertson, and C.M. Thomas. 2006. Effects of predation, flooding, and contamination on reproductive success of California clapper rails (*Rallus longirostris obsoletus*) in San Francisco Bay. The Auk 123(1):45–60. https://doi.org/10.1093/auk/123.1.45

Smith, P.M. 1975. Habitat requirements and observations on the clapper rail, *Rallus longirostris yumanensis*. M.S. thesis. Arizona State University, Tempe, Arizona. 35 p.

Trathnigg, H.K. and F.O. Phillips. 2015. Importance of native understory for bird and butterfly communities in a riparian and marsh restoration project on the Lower Colorado River, Arizona. Ecological Restoration 33(4):395–407.

_____. 2017. Riparian and Wetland Restoration Effects on Bird and Butterfly Communities on the Colorado River. Pages 37–41 *in* B.E. Ralston and D.A. Sarr (editors). Case Studies of Riparian and Watershed Restoration in the Southwestern United States—Principles, Challenges, and Successes. U.S. Geological Survey Open-File Report 2017-1091.

Tsao, D.C., J.Y. Takekawa, I. Woo, J.L. Yee, and J.G. Evens. 2009. Home range, habitat selection, and movements of California black rails at tidal marshes at San Francisco Bay, California. The Condor 111(4):599–610. https://doi.org/10.1525/cond.2009.090004

U.S. Fish and Wildlife Service (USFWS). 2010. Yuma Clapper Rail (*Rallus longirostris yumanensis*) Recovery Plan: Draft First Revision. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 73 p.

_____. 2013. Designation of critical habitat for southwestern willow flycatcher; final rule. Federal Register 78(2):344–534.

_____. 2017. Species Fact Sheet: Yuma Ridgway's Rail. Arizona Ecological Services Office, Phoenix, Arizona.

USFWS (see U.S. Fish and Wildlife Service).

Wood, D.A., T.V.D. Bui, C.T. Overton, A.G. Vandergast, M.L. Casazza, J.M. Hull, and J.Y. Takekawa. 2017. A century of landscape disturbance and urbanization of the San Francisco Bay region affects the present-day genetic diversity of the California Ridgway's rail (*Rallus obsoletus obsoletus*). Conservation Genetics 18(1):131–146. https://doi.org/10.1007/s10592-016-0888-4

ACKNOWLEDGMENTS

The authors of the original CLRA conceptual ecological model in 2015 acknowledged Chris Dodge and Joe Kahl, Jr., biologists with the Reclamation, LCR MSCP; Sonja Kokos, Adaptive Management Specialist, LCR MSCP, who provided invaluable technical feedback and guidance during the development of the model process and production of that original report; and John Swett, Program Manager, LCR MSCP, for his leadership and support of the LCR MSCP conceptual ecological modeling effort.

The authors of this updated CLRA conceptual ecological model acknowledge additional invaluable technical feedback from Chris Dodge, Joe Kahl, Jr., and Carolyn Ronning, biologists, LCR MSCP; Becky Blasius, Adaptive Management Specialist, LCR MSCP; and Jimmy Knowles, Adaptive Management Group Manager, LCR MSCP.

ATTACHMENT 1

Yuma Clapper Rail (*Rallus longirostris yumanensis* Dickey) (CLRA) Habitat Data

Table 1-1.—Yuma clapper 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	CLRA diet dominated by crayfish (*Procambarus* sp., *Orconectes* sp.)	California	Anderson and Ohmart 1985; Conway et al. 1993; Eddleman 1989; Eddleman and Conway 2020
	Crayfish abundance highest in moderately dense cattails (*Typha* sp.) or very dense cattails	Topock Marsh; Lower Colorado River; Salton Sea	Bennett and Ohmart 1978; Smith 1975
	Crayfish abundance highest in late April to mid-May and lowest in winter	Salton Sea	Bennett and Ohmart 1978
Genetic Diversity	No quantifiable values found in the literature		
Infectious Agents	No quantifiable values found in the literature		
Local Hydrology	Some water < 30 centimeters deep around margins of marsh during nesting season	Lower Colorado River	Conway et al. 1993
	Stable water levels	California; Lower Colorado River	Anderson and Ohmart 1985; Gould 1975
	Tolerant of highly fluctuating water depths	Imperial National Wildlife Refuge (Imperial NWR)	Nadeau et al. 2011
	Deeper water necessary in winter	Lower Colorado River	Conway et al. 1993
	0–65 millimeters of water	Imperial NWR	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	Breeding season = 7–8 hectares (ha); post-breeding season = 15 ha; late winter = 24 ha	Lower Colorado River	Conway et al. 1993
	Large-scale management units = 150 ha	Lower Colorado River	Eddleman 1989
	Minimum patch size = 8 ha	Salton Sea	Bailey et al. 1983
	CLRA density = 1 pair/13.5 ha	Topock Marsh; Lower Colorado River	Smith 1975
	Year-round home range average = 7.5 ha	Lower Colorado River	Rosenberg et al. 1991
Predators	No quantifiable values found in the literature		
Residual Vegetation Density	CLRA avoid areas with heavy accumulation of dead emergent vegetation	Lower Colorado River	Conway et al. 1993; Conway et al. 2010

Table 1-1.—Yuma clapper rail habitat data

Habitat element	Value or range	Location	Reference
Site Topography	May select areas with higher ground for their nests, such as edges of tidal sloughs, jetties, and levees	Rangewide	Anderson and Ohmart 1985; Eddleman 1989; Eddleman and Conway 2020
Vegetation Community Type	Moderately dense cover of cattails and bulrush (Cyperaceae)	Lower Colorado River	Anderson and Ohmart 1985; Eddleman 1989; Gould 1975
	Vegetation height > 2 meters	Lower Colorado River	Anderson and Ohmart 1985; Eddleman 1989
	Promote southern cattails (*Typha domingensis*) in deeper water areas (> 30 millimeters)	Imperial NWR	Nadeau et al. 2011
	Probability of occupancy negatively associated with river bulrush (*Schoenoplectus robustus*) and positively associated with southern cattails and phragmites (*Phragmites australis*)	Imperial NWR	Nadeau et al. 2011
	Tolerant of some tamarisk (*Tamarix* sp.) and tree cover	Lower Colorado River	Eddleman 1989; U.S. Fish and Wildlife Service 2010
	Low densities of river bulrush and moderate densities of phragmites and southern cattails	Lower Colorado River	Nadeau et al. 2011
Vegetation Density	Low to moderate stem densities < 80 stems/square meter coupled with shallower water in nesting season	Lower Colorado River	Conway et al. 1993
	Lower basal cover coupled with deeper water in winter	Lower Colorado River	Conway et al. 1993
	Low densities of river bulrush and moderate densities of phragmites and southern cattails	Lower Colorado River	Nadeau et al. 2011

Note: The data presented in this table reflect those available in the literature at the time this model was updated. These data have not been validated.

ATTACHMENT 1 – LITERATURE CITED

Anderson, B.W. and R.D. Ohmart. 1985. Habitat use by clapper rails in the Lower Colorado River Valley. The Condor 87:116–126.

Bailey, D.A., K.H. Rodenbaugh, V.M.J. Ryden, P.B. Schumann, P.M Merifield, and W.D. Dritschilo. 1983. Enhancement of habitats for the Yuma Clapper Rail and Desert Pupfish, in the vicinity of the Salton Sea, California. Report ESE 83-52. Prepared for Southern California Edison Environmental Science and Engineering, University of California, Los Angeles, California. 107 p.

Bennett, W.W. and R.D. Ohmart. 1978. Habitat Requirements and Population Characteristics of the Clapper Rail (*Rallus longirostris yumanensis*) in the Imperial Valley of California. University of California, Lawrence Livermore Laboratory, Livermore, California. 55 p.

Conway, C.J., W.R. Eddleman, S.H. Anderson, and L.R. Hanebury. 1993. Seasonal changes in Yuma clapper rail vocalization rate and habitat use. Journal of Wildlife Management 57(2):282–290.

Conway, C.J., C.P. Nadeau, and L. Piest. 2010. Fire helps restore natural disturbance regime to benefit rare and endangered marsh birds endemic to Colorado River. Ecological Applications 20:2024–2035.

Eddleman, W.R. 1989. Biology of the Yuma Clapper Rail in the Southwestern U.S. and Northwestern Mexico. Final report to the Bureau of Reclamation, Yuma Projects Office, and Fish and Wildlife Service, Region 2. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, Wyoming. 127 p.

Eddleman, W.R. and C.J. Conway. 2020. Ridgway's rail (*Rallus obsoletus*), version 1.0 *in* P.G. Rodewald (editor). Birds of the World. Cornell Lab of Ornithology, Ithaca, New York. https://doi.org/10.2173/bow.ridrai1.01

Gould, G.I. 1975. Yuma Clapper Rail Study – Censuses and Habitat Distribution 1973–74. Wildlife Management Branch Administrative Report No. 75-2. State of California, Department of Fish and Game. 24 p.

Nadeau, C.P., C.J. Conway, M.A. Conway, and M. Ogonowski. 2011. Restoration of Managed Marsh Units to Benefit California Black Rails and Other Marsh Birds: An adaptive Management Approach, Final Report. Wildlife Research Report #2011-01. U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, Tucson, Arizona, USA.

Rosenberg, K.V., R.D. Ohmart, W.C. Hunter, and B.W. Anderson. 1991. Birds of the Lower Colorado River Valley. The University of Arizona Press, Tucson, Arizona. 416 p.

Smith, P.M. 1975. Habitat requirements and observations on the clapper rail, *Rallus longirostris yumanensis*. M.S. thesis. Arizona State University, Tempe, Arizona. 35 p.

U.S. Fish and Wildlife Service. 2010. Yuma Clapper Rail (*Rallus longirostris yumanensis*) Recovery Plan: Draft First Revision. U.S. Fish and Wildlife Service, Albuquerque, New Mexico. 73 p.