Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2019 Updates to Gilded Flicker (*Colaptes chrysoides*) (GIFL) Basic Conceptual Ecological Model for the Lower Colorado River

Photo courtesy of Curtis Marantz

November 2020

Work conducted under LCR MSCP Work Task G6

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Lower Colorado River Multi-Species Conservation Program

2019 Updates to Gilded Flicker (*Colaptes chrysoides*) (GIFL) Basic Conceptual Ecological Model for the Lower Colorado River

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November 2020

Johnson, E.A. and R. Unnasch. 2020. 2019 Updates to Gilded Flicker (*Colaptes chrysoides*) (GIFL) 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

CAP	critical biological activity or process
CEM	conceptual ecological model
CF	controlling factor
GBBO	Great Basin Bird Observatory
GIFL	gilded flicker (*Colaptes chrysoides*)
HE	habitat element
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
LSO	life-stage outcome
N/A	not applicable
Reclamation	Bureau of Reclamation
WNV	West Nile Virus

Symbols

>	greater than
≥	greater than or equal to
°C	temperature in degrees Celsius (*aka* Centigrade)
°F	temperature in degrees Fahrenheit
%	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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Attachment

1 Gilded Flicker (*Colaptes chrysoides*) (GIFL) 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 gilded flicker (*Colaptes chrysoides*) (GIFL) (Johnson and Unnasch 2015). This update incorporates information reported in publications and presentations at professional meetings since the completion of the original GIFL 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 update 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 do not significantly change the original GIFL conceptual ecological model. However, updates to names and definitions improve consistency among models, and new information strengthens existing discussion. This update adds two new habitat elements: Anthropogenic Disturbance, to enable the CEM to better address possible effects of human activity on GIFL, and Genetic Diversity. Some link interaction strengths have been modified, in particular that of Grazing, to more accurately reflect current conditions at Bureau of Reclamation sites.

This report also provides a list of all literature cited in the updates to chapters 1–6. In addition, it provides a list of all changes made to the name of the CEM components 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 GIFL. 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 3 in the initial section of chapter 1 is updated as follows:

The most widely used sources of information for the gilded flicker (*Colaptes chrysoides*) (GIFL) conceptual ecological model are Bureau of Reclamation (Reclamation) (2008, 2016), Moore et al. (2020), and NatureServe (2019). Where appropriate and accessible, those earlier studies are directly cited. These publications summarize and cite large bodies of earlier studies. 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 River Multi-Species Conservation Program (LCR MSCP) biologists, including Best (2017), Best et al. (2015, 2017), Chavez (2017), and Sabin (2012). In addition, pertinent references for other flicker species were used to supplement the basic information from the lower Colorado River (LCR). The purpose of a 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 GIFL REPRODUCTIVE ECOLOGY

The discussion is updated as follows:

GIFL are considered year-round residents of the LCR (Reclamation 2016 and references therein). In late winter or early spring, breeding adults form pair bonds and begin nest excavation (B. Sabin and M.E. Chavez 2014, personal communication) preferably in saguaro cacti (*Carnegiea gigantea*) (Moore et al. 2020). Occasionally, they will reuse old cavities rather than excavate new ones (B. Sabin 2018, personal communication). Egg laying peaks from mid-April to mid-May (Corman 2005; Rosenberg et al. 1991), with an average of four eggs laid per clutch. Both parents incubate during the 11–12 day incubation period (NatureServe 2019) and tend to the hatched young. Fledging occurs in 21–27 days (Moore et al. 2020; Reclamation 2016), and juvenile flickers may remain with their parents as part of “family groups,” foraging together at least through July (B. Sabin and M.E. Chavez 2014, personal communication). There is little information about juvenile movements post-fledging or overwintering behavior and habitat use, as juveniles are difficult to detect (Best et al. 2015). GIFL feed mainly on insects during the spring and summer months (mostly ants, followed by beetles, grasshoppers, caterpillars, and other larvae). In addition, they will supplement their diet with seeds, berries, and other fruits (Bent 1939), regularly visiting shrubs and herbs to feed (Best et al. 2017; Sabin 2012).

Typical GIFL breeding habitat consists of Sonoran desert with saguaro cacti in which flickers construct nest cavities. Flickers forage for ground insects, mainly ants, and other insects in shrubs in desert habitats but will also visit nearby riparian areas to forage (Corman 2005; Rosenberg et al. 1991). Riparian habitats with cottonwoods (*Populus fremontii*) and willows (*Salix* sp.) have been documented to supported GIFL in the past (Reclamation 2016).

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 GIFL

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

Updates to Chapter 2 – GIFL Life-Stage Model

This update standardizes the names of the GIFL 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 (at the end of this chapter) are updated accordingly.

Update to Introduction to the GIFL Life Cycle

GIFL are year-round residents of the LCR, so we have developed a four-stage model that includes an overwintering life stage. Also, in many studies of avian demography, nest survival is considered integral in the reproduction of adults because adults are heavily invested in the care of eggs and nestlings (Etterson et al. 2011). We treat the eggs/nestlings stage as separate from adult reproduction due to the specific factors influencing the nest and the fit with the life-stage outcome modelling structure used in this CEM process.

We have chosen to combine the egg and nestling phases of development into an eggs/nestlings life stage because both the eggs and nestlings occupy the same nest; therefore, management focused on the nest will affect both eggs and nestlings. Further, most research conducted on GIFL breeding has focused on the number of young fledged and not on the number of eggs hatched—meaning that most of the available information is on the habitat characteristics and management actions associated with success of the nest through both incubation and brooding periods.

Update to GIFL Life Stage 1 – Eggs/ Nestlings

This life stage includes both the egg and nestling phase. It begins when the first egg is laid and ends when the young fledge or if the nest fails. Peak egg laying activity occurs from mid-April to mid-May, although eggs may be laid earlier in March in some locations (Corman 2005; Rosenberg et al. 1991). For example, in 2014, the earliest recorded egg date at Quartzite, Arizona, was March 27

(Best et al. 2017). An average of four eggs are laid per clutch, with one brood per season most likely, although there are records of double brooding (Best et al. 2017; Rosenberg et al. 1991). Incubation, by both parents, begins after the clutch is complete and lasts around 11–12 days (NatureServe 2019). Both parents attend the nest after the eggs hatch, feeding young with regurgitant (Bent 1939). The young typically fledge in about 21–27 days (Moore et al. 2020; NatureServe 2019; Reclamation 2016); however, there is no information on nestling survivorship. The life-stage outcome from the eggs/nestlings stage is the survival of eggs and associated nestlings. It is important to note that the outcome of the nest stage is inherently tied to the behavior and condition of the parents, in addition to other factors.

Update to GIFL Life Stage 2 – Juveniles

The juveniles life stage is relatively short and lasts from the time the birds fledge and leave the nest until they molt into their first winter plumage in fall. There is no information on how long the recently fledged young remain in the vicinity of the nest and/or with adults, as they are difficult to detect, although LCR biologists have observed "family groups" of flickers foraging together through July (Best et al. 2015; B. Sabin and M.E. Chavez 2014, personal communication). The life-stage outcome from the juveniles life stage is the survival of the bird from successfully leaving the nest and fledging to molting into winter plumage later in fall.

Update to GIFL Life Stage 3 – Overwintering Individuals

The overwintering individuals life stage includes both post-breeding adult birds and juvenile GIFL from the time the juvenile birds molt into their first winter plumage until they are ready to breed the following spring. (Northern flickers [*Colaptes auratus*] reach sexual maturity the following spring, so it is assumed that the same holds true for GIFL [Moore et al. 2020]). GIFL are considered year-round residents and do not migrate (Reclamation 2016 and references therein). Most GIFL remain in the vicinity of their breeding area during the summer months post-breeding (Best et al. 2015, 2017) and likely throughout the year, although some birds may make seasonal movements (Chavez 2017). Brush et al. (1983) observed that large numbers of northern flickers moved into the LCR over the winter months. The life-stage outcome from the overwintering individuals life stage is the survival of the bird post-molt to become a breeding adult along the LCR.

GIFL Life Stage 4 – Breeding Adults

This life stage is updated as follows:

The breeding adults life stage begins with pair bonding and nest excavation, usually beginning in January and February along the LCR (B. Sabin and M.E. Chavez 2014, personal communication). Saguaro cacti are preferred nest sites (Gilman 1915), and although both parents excavate the cavity, the males may play a larger role (Kilham 1983; Lawrence 1966). Excavation is typically done early in the season and may take 3 months (Juarez 2010), as cacti holes need time to cure before they can be used. GIFL will sometimes reuse old cavities (Sabin 2018, personal communication). The breeding adults stage life ends when the young are successfully fledged and are foraging completely on their own.

The life-stage outcomes for breeding adults are survival and fertility. The CEM defines the latter as the rate of production of viable eggs by cohorts of breeding adults. Since GIFL eggs are not viable unless fertilized and laid in a nest that is safely constructed, safely located, and well attended, all of these contribute to breeding adult fertility. Fertility is distinguished from fecundity, which is the rate of recruitment of offspring to the next generation (Etterson et al. 2011). In the structure of the present CEM, the fecundity rate would be recognized as a function of both (1) adult survival and fertility in the breeding adults life stage and (2) egg-nestling survival in the eggs/nestlings life stage, the latter of which depends significantly on nest success. Here we have separated the eggs/nestlings life 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.—(Revision of original table 1) GIFL life stages and outcomes in the LCR ecosystem

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

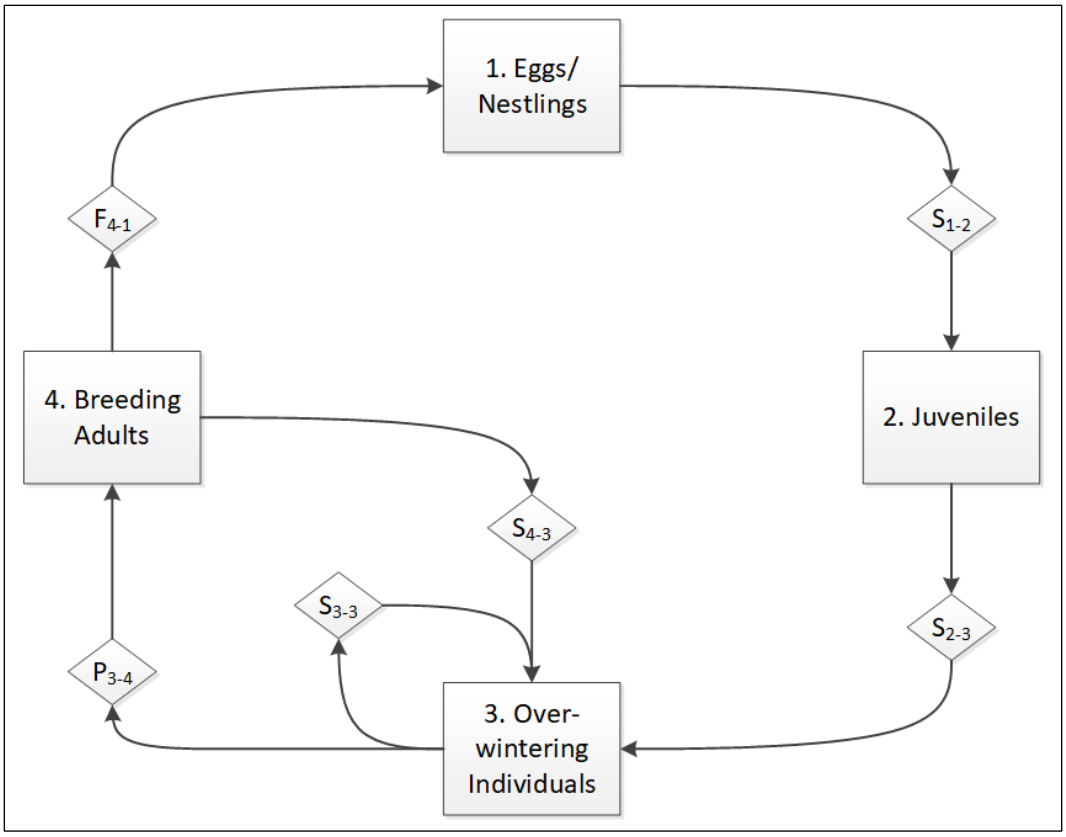

Figure 1.—(Revision of original figure 1) Proposed GIFL life history model. Squares indicate the life stage, and diamonds indicate the life-stage outcomes. S_{1-2} = survival, eggs/nestlings; S_{2-3} = survival, juveniles; S_{3-3} = annual survival of overwintering individuals that do not breed; P_{3-4} = annual participation of adults in breeding; S_{4-3} = survival, breeding adults; and F_{4-1} = fertility, breeding adults.

Updates to Chapter 3 – Critical Biological Activities and Processes

This update changes the names of two critical biological activities and processes, Molt and Temperature Regulation, and replaces them with Molting and Thermal Stress, for consistency with the other LCR MSCP conceptual ecological model updates. In addition, Competition has been changed to Nest Cavity Competition to better align with how competition is addressed in the GILA conceptual ecological model and to clarify the type of competition that is potentially most critical to GIFL. A new critical biological activity and process, Nest Predation, also has been added for consistency with other bird models. As a result, the CEM now has 10 critical biological activities and processes. Nine habitat elements have been updated with additional information. Table 2 is updated to reflect these changes as follows:

Table 2.—(Revision of original table 2) Distribution of GIFL critical biological activities and processes among 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**	**Overwintering individuals**	**Breeding adults**
Disease	X	X	X	X
Eating	X			
Foraging		X	X	X
Molting (*renamed*)	X	X		X
Nest attendance				X
Nest cavity competition (*renamed*)				X
Nest predation (*new*)	X			
Nest site selection				X
Predation		X	X	X
Thermal stress (*renamed*)	X	X		X

DISEASE

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

This process refers to diseases caused either by lack of genetic diversity or by infectious agents. Although there is little information available about GIFL in relation to disease susceptibility (Moore et al. 2020), GIFL in all life stages are conceivably susceptible to disease. In recent years, West Nile Virus (WNV) has spread into the Western United States. Although corvids and raptors appear to be more vulnerable to WNV (e.g., during initial 1999 outbreak, American crows experienced 100% mortality in the Eastern United States when infected [Reed et al. 2009]), the disease can still kill or weaken other bird species, including flickers. As the disease has spread West, however, it has become less virulent due to a dilution effect (Koenig et al. 2010).

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 nestlings must eat to stay alive and develop but do not actively forage within their environment in the same way as juveniles and adults. A nestling's ability to eat during the first weeks of life is determined by the foraging and provisioning rate of its parents. (Juveniles may still be fed by adults for some time after fledging [see chapter 4, "Parental Care"].)

FORAGING

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

GIFL are mainly insectivores, feeding predominantly on ants, as well as beetles and other soil invertebrates, and occasionally on seeds and berries depending on insect availability (Moore et al. 2020). Foraging is done by juveniles and adults; however, it is important to note that the foraging of parents affects the provisioning rate to nestlings and juveniles (see chapter 4, "Parental Care").

MOLTING

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

Molting 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 (Howell 2010). Molting is an energetically costly process that may make nestlings more susceptible to death when resources are scarce (Gill et al. 2019; Howell 2010). GIFL are altricial and must molt from natal down into juvenal plumage to fledge. Juveniles then undergo an incomplete pre-basic (pre-formative) molt from June to October (Chavez 2017; Pyle 1997). Adults undergo an incomplete to complete pre-basic molt from June to October every subsequent year of their lives (Chavez 2017; Pyle 1997). Despite the range of dates, in the LCR, molting for these birds occurs mainly in October (Chavez 2017). Adult GIFL do not undergo a pre-alternate molt (Pyle 1997). This activity applies to the eggs/nestlings, juveniles, and the breeding adults life stages.

NEST ATTENDANCE

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

Both males and females incubate, brood, and feed young chicks (Moore et al. 2020). Nest attendance is performed by both breeding adults (and is dependent in part on their survivorship) and affects the eggs/nestlings life stage (egg hatching and the provisioning rate to nestlings).

NEST CAVITY COMPETITION

This critical biological activity and process, formerly named Competition, is renamed Nest Cavity Competition for consistency with the Gila woodpecker model and to clarify its meaning. Further, the definition of this critical process is revised to include additional information about European starling (*Sturnus vulgaris*) competition.

This process refers specifically to competition for nest cavities with European starlings, which have been identified as a concern in the LCR, particularly for Gila woodpeckers (Kerpez and Smith 1990). Although GIFL were less affected in that study, northern flickers have been shown to delay nesting in response to

starling competition for nest cavities (Ingold 1996). Starlings have not been observed in revegetated conservation areas in the LCR, so any competition for nest cavities from this species may not be a significant management concern for GIFL at this point in time (J. Kahl, Jr. 2018, personal communication). In addition, GIFL predominantly use cacti for nesting in the LCR, and starlings rarely use the upland desert habitat where saguaros occur (B. Sabin 2018, personal communication).

NEST PREDATION

This critical biological activity or process is a new addition to the CEM, added for consistency with other bird models. It only applies to the eggs/nestlings life stage and is defined as follows:

Nest predation is a threat to GIFL and obviously affects nestling survival to varying degrees. Young GIFL in the nest are vulnerable to reptiles such as rat snakes (*Elaphe* sp.) and gophersnakes (*Pituophis catenifer*) (Bent 1939). Although some common nest predators of GIFL are known (see chapter 4, "Nest Predators"), the rate of predation at the eggs/nestlings life stage is not known. (*Note*: Even if cavity nesters experience relatively less predation than open cup nesters, nest predation is still the largest source of nest loss overall, causing up to 80% of nest failures [Martin 1993].)

NEST SITE SELECTION

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

GIFL preferentially nest in mature saguaro cacti, with older records of nesting reported in riparian cottonwoods and/or willows "within the valley proper" (the LCR Valley) (B. Raulston 2019, personal communication; Reclamation 2016 and references therein; Rosenberg et al. 1991) (*Note*: No breeding in LCR riparian habitat has been confirmed in recent years, although birds have been observed visiting the habitat – see Sabin 2012). It is unknown whether the male or female selects the site (Moore et al. 2020). Both parents excavate the nest hole, with males playing a larger role (Kilham 1983; Lawrence 1966).

In general, nest placement can affect vulnerability to predation and competition, environmental conditions in the nest cavity, and foraging rates, depending on proximity to food resources. Inouye et al. (1981) found that Gila woodpeckers oriented their nest cavity entrances non-randomly, in a northerly direction (avoiding direct sunlight). Similarly, research by Zwartjes and Nordell (1998)

found that GIFL nest cavities in cardón cacti (*Pachycereus pringlei*) in Mexico were typically oriented to the north or northwest, although this was modified depending on cacti architecture. A cavity entrance with greater visibility may also enhance nest protection efforts against predators (Zwartjes and Nordell 1998). Best et al. (2015) found that most GIFL nest cavities observed at Quartzite, Arizona, were also oriented to the northwest or northeast. In addition to the cavity entrance orientation effect on nest temperature, the thick saguaro cactus tissue may provide additional buffering. Environmental conditions in the nest are important, as Wiebe (2001) found that clutch size in northern flickers was affected by cavity temperature (and therefore by cavity orientation and substrate).

PREDATION

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

Predation is a threat to GIFL in all life stages, and it obviously affects survival to varying degrees. Although the most common predators of juveniles, overwintering individuals, and breeding adult GIFLs are well-known (see chapter 4, "Predators"), the rates of predation at any life stage are not known. Adult northern flickers are particularly vulnerable to avian predators, especially raptors (Fisher and Wiebe 2006), as they typically feed on open ground in search of ants and other soil invertebrates. GIFL will feed on insects in shrubs and other vegetation, including mesquite (*Prosopis* sp.) trees (B. Sabin 2018, personal communication), yet they, too, predominantly feed on ground ants so likely experience a similar susceptibility to avian predators as northern flickers. Susceptibility of northern flickers to predation is not only related to ground cover (as they feed mostly on the ground) but also to nest location (e.g., height above the ground and vegetation cover at the nest entrance) (Wiebe 2001).

THERMAL STRESS

This critical biological activity or process, formerly named Temperature Regulation, is renamed Thermal Stress for consistency with other CEMs and to clarify its meaning.

Avoiding thermal stress is important for any organism inhabiting a region with temperatures as high as that of the LCR. Although overheating is possible during all life stages, most of the concern has been directed at eggs and nestlings (Rosenberg et al. 1991). However, adults can moderate the thermal stress of eggs and nestlings through their own behavior (e.g., incubation or brooding) and through nest placement and construction. For example, northern flicker cavity placement in larger trees (versus those with smaller trunks or with more dead

wood) has been shown to moderate daily temperature and humidity fluctuation, as does the orientation of the cavity opening (Wiebe 2001). Inouye et al. (1981) demonstrated that the orientation of Gila woodpecker cavities in saguaro were non-random, directed in a northerly direction. GIFL may face more thermal stress than smaller woodpeckers in desert regions, and the orientation of GIFL cavities in cardón cacti in Mexico is also usually in a north-northwesterly direction, facing away from direct sun and possibly capturing prevailing winds (Zwartjes and Nordell 1998). Best et al. (2015) found that most GIFL nest cavities observed at Quartzite, Arizona, were also oriented to the northwest or northeast. In addition to the cavity entrance orientation effect on nest temperature, the thick saguaro cactus tissue may provide additional buffering. For these reasons, temperatures inside saguaro cacti nest cavities of GIFL may be markedly cooler in summer than outside daytime air temperatures. Soule (1964) reported GIFL cavity nest temperatures were an average of 12.6 °F (7 °C) cooler than ambient temperatures.

Research on cactus cavities used by ferruginous pygmy-owls (*Glaucidium brasilianum cactorum*) in southwestern deserts demonstrated that cactus tissue buffers daily temperature swings, with cavities being slightly warmer at night and slightly cooler during the day as compared to outside temperatures (Lowery and Ingraldi 2003). In this update, we have not included thermal stress for the overwintering life stage; however, if further information becomes available, it can be included in future revisions.

Updates to Chapter 4 – Habitat Elements

This update standardizes the name of two habitat elements, with Brood Size becoming Brood/Litter Size and Predator & Competitor Density becoming Predators. Four new habitat elements have been created: Anthropogenic Disturbance, Genetic Diversity, Nest Cavity Competitors, and Nest Predators, and two habitat elements (Parental Nest Attendance and Parental Feeding Behavior) have been combined to form a new element, Parental Care, for consistency with other bird models. Eight habitat elements have been updated with additional information. Table 3 is updated to reflect these changes as follows:

Table 3.—(Revision of original table 3) Distribution of GIFL habitat elements and the critical biological activities and processes that they directly affect across all life stages

(Xs indicate that the habitat element is applicable to that critical biological activity or process.)

Critical activity or process ➔ **Habitat element 🡻**	**Disease**	**Eating**	**Foraging**	**Molting (*renamed*)**	**Nest attendance**	**Nest cavity competition (*renamed*)**	**Nest predation (*new*)**	**Nest site selection**	**Predation**	**Thermal stress (*renamed*)**
Anthropogenic disturbance (*new*)								X		
Brood/litter size (*renamed*)		X	X		X					
Food availability			X					X		
Foraging habitat									X	
Genetic diversity (*new*)	X									
Infectious agents	X									
Nest cavity competitors (*new*)						X				
Nest predators (*new*)							X			
Parental care (*renamed*)		X	X				X		X	X
Predators (*renamed*)					X			X	X	
Temperature					X			X		X
Tree cavities (*renamed*)						X		X		

ANTHROPOGENIC DISTURBANCE

This habitat element is a new addition to the CEM, defined as follows:

Full name: **Human activity within or surrounding a given habitat patch, including noise, pollution, and other disturbances associated with human activity**. Whether due to recreational, land management and development, or scientific research activities, the presence of humans can disturb GIFL, causing changes in behavior that might ultimately affect survival. Anthropogenic disturbance can affect both breeding success and the survival of birds (reviewed by Barber et al. 2010; Francis and Barber 2013). Noise might mask conspecific cues such as songs or calls, making it more difficult for GIFL to attract or find mates or defend territories. Further, noise might mask cues used in conspecific attraction, making it difficult for GIFL to find appropriate habitat. Noise can shift the foraging/vigilence tradeoff – either putting an individual at higher risk due to starvation or to predation (Ware et al. 2015). Noise can cause behavioral changes, physiological changes, and species diversity changes within an area. Anthropogenic disturbance is considered to be a habitat element, as it is an environmental characteristic or background condition with which a nesting or foraging flicker must contend.

GIFL tend to avoid populated urban and rural areas even if saguaro cacti are present (Moore et al. 2020; Reclamation 2016; Rosenberg et al. 1991). Turner (2006) observed that, in the Tucson area, GIFL required a high cover (30–50%) of natural desert scrub landscape to persist. Similarly, Clark (2011) reported that the distribution of GIFL declined with increasing urbanization. They were absent from many of the more populated Breeding Bird Survey blocks from the greater Phoenix area, including surrounding agricultural areas (Corman 2005), although from time to time GIFL may take advantage of human provisioning, for example, by regularly visiting bird baths near Quartzite, Arizona (Best et al. 2015) or by foraging in golf course turfgrass (Turner 2006). It is not known whether disturbance affects nest attendance or how GIFL foraging in riparian habitat respond to human disturbance.

BROOD/LITTER SIZE

This habitat element replaces the original, Brood Size, with a slightly updated definition as follows:

Full name: **The number of young in the nest**. This element refers to the number of young that the parents must rear per nest. Brood/litter size is a life-stage outcome for Breeding Adults (fertility) that acts as a habitat element for eggs/nestlings and juveniles. Clutch size is related to maternal health, and the

well-being of both parents depends in part on the availability of sufficient food resources in close proximity to the breeding territory (Gill et al. 2019) as well as other factors such as predator density. The typical GIFL brood consists of four eggs (Koenig 1984).

FOOD AVAILABILITY

The discussion of this habitat element is updated as follows:

Full name: **The abundance of food available for adults and their young**. This element refers to the availability of food resources, whether ants, beetle larvae, or seeds and berries, which individual GIFL will encounter during each life stage, and the density and spatial and temporal distributions of the food supply in proximity to the nest. Flickers feed predominantly on insects during the spring and summer months (mostly ants, followed by beetles, grasshoppers, caterpillars, and other larvae), supplementing their diet with plant matter (seeds and berries) when insects are less abundant (Bent 1939). Other important spring food sources include nectar from ocotillo (*Fouquieria splendens*) and saguaro cacti as well as the saguaro fruits later in the season (Best et al. 2017). Food availability determines, in part, not only clutch size but also winter survivorship (Gill et al. 2019; Koenig 1984).

FORAGING HABITAT

The discussion of this habitat element is updated as follows:

Full name: **The abundance and spatial distribution of suitable foraging habitat**. GIFL feed on ground insects (primarily ants) and other invertebrates. Flickers have also been known to feed on insects in flowers, foraging on ocotillo, palo verde (*Parkinsonia florida*), ironwood (*Olneya*) trees, and on saguaro cacti (Best et al. 2017; B. Sabin and M.E. Chavez 2014, personal communication). In fact, Kerpez and Smith (1990) found that flicker nesting density was positively correlated with ironwood volume. During winter, when insects are less abundant and ant colony populations are smaller (Hölldobler and Wilson 1990), GIFL also will feed on seeds and berries (Terres 1980). For example, they have been observed feeding on mistletoe berries in mesquite (Sabin 2012).

GIFL have a very large home range, even during the nesting season, in which they probably forage (Best et al. 2017; B. Sabin 2018, personal communication). Nesting and foraging habitat used by GIFL near Quartzite, Arizona, included lowlands and arroyos with many saguaro cacti and patches of trees and shrubs as well as rocky outcrops with sparser vegetation and few cacti (Best et al. 2017).

Optimal foraging habitat may include open areas with friable soil suitable for ant colony establishment and maintenance, the presence of flowering shrubs that support insect populations, as well as areas that provide berries and seeds, and may vary throughout the year. Riparian habitats may be used for foraging and roosting (Rosenberg et al. 1991), especially after the young fledge (B. Sabin and M.E. Chavez 2014, personal communication). The Great Basin Bird Observatory (GBBO) (2011) observed a family group foraging in riparian habitat at the Bill Williams River National Wildlife Refuge and an individual GIFL nesting in a saguaro and also foraging in riparian habitat (GBBO 2012). Although there is little information available, the proximity of riparian habitat to saguaro cacti nest sites may be important to successful nesting and/or juvenile or overwintering survival.

GENETIC DIVERSITY

This habitat element is a new addition to the CEM, defined as follows:

Full name: **The genetic diversity within GIFL populations**. 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 (Allendorf and Leary 1986).

GIFL have exhibited high site fidelity (Best et al. 2017), and their nesting territories can be sizeable (Best et al. 2015, 2017); however, there is little information about their capacity for long-distance dispersal post-breeding. In addition, to date, they are restricted to nesting in saguaro habitats, though they will readily forage in riparian forest if in proximity. This habitat combination is limited in the LCR. In the past, GIFL were more common and widespread throughout riparian areas in the LCR (Grinnell 1914; Swarth 1914 in Corman 2005) and likely nested in riparian forests, excavating nest cavities in softer trees such as cottonwoods. However, there remains a lack of large riparian forest habitats in the LCR with trees of sufficient size or with available snags of appropriate internal condition of decay (Lorenz et al. 2015) for them to nest.

In addition, there has been possible evidence of hybridization between GIFL and northern flickers along the LCR (Short 1965). Current populations of northern flickers are either migratory or overwinter in the LCR (B. Sabin 2019, personal communication). However, the northern flicker is generally far more tolerant of human activity (Wiebe and Moore 2020), and if the breeding range of the northern flicker expands into more densely populated areas of the LCR, it may increase the possibility of interbreeding in the future.

INFECTIOUS AGENTS

The discussion of this habitat element is updated as follows:

Full name: **The types, abundance, and distribution of infectious agents and their vectors**. Infectious agents refer to the spectrum of viruses, bacteria, fungi, and parasites capable of infecting GIFL and that individual GIFL are likely to encounter during each life stage. The effects of disease and other infectious agents are poorly understood. In recent years, WNV has spread into the Western United States. Although corvids and raptors appear to be most vulnerable to WNV, the disease can kill or weaken other bird species, including flickers. As the disease has spread West, however, it has become less virulent due to a dilution effect (Koenig et al. 2010). WNV is now well-established, without major impacts to GIFL in the LCR.

NEST CAVITY COMPETITORS

This habitat element is a new addition to the CEM, added for consistency with the Gila woodpecker CEM, and defined as follows:

Full name: **The presence and density of nest cavity competitors that may block or displace nesting GIFL**. Competitors may include European starlings. Starlings are known to compete for nest cavities with other flicker species, but may not be an issue for GIFL, which are larger than Gila woodpeckers, with which starlings usually compete (Kerpez and Smith 1990; Reclamation 2016). Competition from starlings may also differ from habitat to habitat depending on which communities support more starlings and whether cavities are a limiting factor. In fact, starlings have not been observed in revegetated conservation areas in the LCR, so any competition for nest cavities from this species may not be a management concern for GIFL at this time, although this could change as sites mature (J. Kahl, Jr. 2018, personal communication).

Although both Gila woodpeckers and GIFL use saguaro cacti for nesting, they excavate their cavities in different parts of the cactus, with the larger GIFL excavating in the top 3 meters (10 feet) of a stem where the skeletal tissue is softer (MacAuliffe and Hendricks 1988). For this reason, competition with other woodpeckers is probably not a strong factor in nest site location.

NEST PREDATORS

This habitat element is a new addition to the CEM, added for consistency with other bird models, and defined as follows:

Full name: **The abundance and distribution of species that depredate GIFL during the eggs/nestlings life stage**. This element refers to a set of closely related variables that affect the likelihood that different kinds of nest predators will encounter and successfully prey on GIFL during the eggs/nestlings life stage. The variables of this element include the species and size of the fauna that prey on GIFL during this life stage, the density and spatial distribution of these fauna in the habitat used by GIFL, and the ways in which predator activity may vary in relation to other factors such as time of day.

PARENTAL CARE

This habitat element replaces the former elements, Parental Feeding Behavior and Parental Nest Attendance, with a slightly updated definition as follows:

Full name: **The ability and behavior of parents to provide care to nests, eggs, nestlings, and juveniles after they fledge from the nest**. This element refers to the capacity of both parents to share nesting and brood-rearing responsibilities until fledging and to provision food for recently fledged birds. The care provided by one or both parents can 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, the presence of predators and competitors, and the ability to thermoregulate.

The average duration that juvenile GIFL are fed after fledging is unknown in this species, although Best et al. (2017) observed family groups with fledglings on two June dates (June 7 and 16, 2014) during their study. The feeding rate is dependent upon food availability and the number of young in the brood. This rate influences the amount of food and time spent foraging by the juvenile birds.

PREDATORS

This habitat element replaces the original, Predator/Competitor Density, for consistency with other bird models and the Gila woodpecker model. All references to competition have been removed and instead incorporated into a new habitat element, Nest Cavity Competitors. The definition and discussion are updated as follows:

Full name: **The abundance and distribution of species that depredate GIFL during the juveniles, overwintering individuals, 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 GIFL during any life stage. The variables of this element include the species and sizes of the fauna that prey on or compete with GIFL during different life stages and the density and spatial distribution of these fauna in the riparian or desert habitat used by GIFL. Predators typically include raptors and crows; mammals, including raccoons (*Procyon lotor*) and weasels (*Mustela* sp.); lizards; and gophersnakes (Bent 1939; Kucera 1997). Susceptibility of northern flickers to predation is related to ground cover (as they feed mostly on the ground) and nest location (e.g., height above the ground and vegetation cover at the nest entrance) (Wiebe 2001), and this is likely the case for GIFL, as they have similar feeding behavior. Little is known about depredation rates of juveniles or adults. The effect of predators can have impacts more subtle than survival by altering prey behavior, nest site selection, breeding behavior, and foraging behavior (Chalfoun and Martin 2009; Lima 1998, 2009).

TEMPERATURE

The discussion of this habitat element is updated as follows:

Full name: **The maximum temperature in a habitat patch or nest site**. This element refers to the maximum temperature in the nesting habitat around the nest site (or during the nesting season). High temperatures typical of the LCR region in summer can kill eggs and stress young in the nest (Rosenberg et al. 1991). The optimal temperature for egg development is generally 37–38° C, with exposure to temperatures higher than 40.5 °C potentially lethal (Gill et al. 2019). Best et al. (2015) measured July temperatures higher than 46 °C (114.8 °F) in the saguaro nesting area at Quartzite, Arizona. However, adults can moderate the temperature of eggs and nestlings through their own behavior (incubation, brooding, or shading) and through nest placement and construction.

TREE CAVITIES

This habitat element replaces the original, Cavity Trees, with a slightly updated definition and discussion as follows:

Full name: **The abundance and spatial distribution of the arborescent cacti or tree species in which GIFL nest or use as roost sites**. The presence of nesting sites for cavity construction, in particular saguaro cacti, but may include cottonwood, willow, and in some cases, honey mesquite (*Prosopis glandulosa*) along the LCR (Reclamation 2016). In southern Nevada and northwestern Arizona, GIFL also use mature Joshua trees (*Yucca brevifolia*) and other yuccas (Floyd et al. 2007; B. Raulston 2019, personal communication). Cacti and nest trees, if used, must be of sufficient size and condition to support cavity excavation. GIFL typically excavate their nest cavity toward the top of saguaro cacti, within 3 meters (10 feet) of the cactus apex (MacAuliffe and Hendricks 1988), and in one study, they did not nest in saguaros less than 5 meters (16 feet) tall (Kerpez and Smith 1990). GIFL will often rework and use existing cacti cavities (B. Sabin 2018, personal communication).

GIFL also use cacti cavities for roosting during the breeding and non-breeding seasons. Males and females typically use separate roost cavities, entering the roost between sunset and dark, and leaving the roost site within a half hour of sunrise (Best et al. 2015; B. Sabin 2018, personal communication). Fledged juveniles may roost in dense shrub cover as opposed to roosting in cacti cavities (Best 2017; B. Sabin 2018, personal communication).

Brush et al. (1983) observed that large numbers of northern flickers also move into the LCR over the winter months and that the availability of cavities for winter roosting may be as important for woodpeckers generally as it is for nesting in summer.

Updates to Chapter 5 – Controlling Factors

This update changes the names of one controlling factor, Pesticide/Herbicide Application, to Pesticide Application. Three controlling factors (Grazing, Nuisance Species Introduction & Management, and Water Storage-Delivery System Design & Operation) also have been updated, as well as table 4, as follows:

Table 4.—(Revision of original table 4) Habitat elements directly affected by controlling factors

Controlling factor ➔ / **Habitat element 🡻**	**Fire management**	**Grazing**	**Nuisance species introduction & management**	**Pesticide application(*renamed*)**	**Planting regime**	**Site management**	**Water storage-delivery system design & operation**
Anthropogenic disturbance (*new*)	N/A*						
Brood/litter size (*renamed*)	N/A*						
Food availability		**X**		**X**		**X**	**X**
Foraging habitat	**X**	**X**	**X**		**X**	**X**	**X**
Genetic diversity (*new*)				N/A*			
Infectious agents			**X**				**X**
Nest cavity competitors (*new*)			**X**				
Nest predators (*new*)			**X**				
Parental care (*renamed*)	N/A*						
Predators (*renamed*)			**X**				
Temperature	N/A*						
Tree cavities (*renamed*)	**X**	**X**	**X**		**X**		**X**

* N/A values suggest that none of the identified controlling factors *directly* affect the habitat element. Brood/litter size and parental care are affected indirectly through other habitat elements. Temperature is determined by regional climate and local weather conditions. Anthropogenic disturbance and genetic diversity are new habitat elements; however, the direct effect of any controlling factors on these elements is not yet understood.

We considered adding nest box/artificial snag installation as a new controlling factor, as the creation of more snags for nesting is an identified conservation measure for GIFL. According to Beth Sabin, nest box installation would be a more appropriate measure for GIFL than snag creation, as GIFL are less likely to excavate their own cavity in hardwood (versus cactus) and will readily reuse old cavities (B. Sabin 2018, personal communication). Cavities have been identified as a potential limiting factor for nesting in riparian areas, and nest box/artificial snag installation conservation measures were intended to provide supplemental nesting sites until the restored riparian forests matured sufficiently to generate their own natural snags and for cavity nesting species to create cavities. There are designs for nest boxes for northern flickers and research on their successful use. This information can serve as a resource should the installation of nest boxes or artificial snags be added to the model and implemented in the future as a management action (B. Sabin 2018, personal communication).

FIRE MANAGEMENT

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 GIFL or their habitat. Effects may include the creation of habitat that supports or excludes GIFL or reduces the food supply for ants and other ground invertebrates on which GIFL feed. (*Note*: The underground location of many ant colonies can buffer them from direct mortality from fire [Andersen 1991]). Although typically not a major threat in most riparian habitats, severe wildfires have affected cottonwood-willow riparian habitat in the past decade (Graber et al. 2007). The U.S. Fish and Wildlife Service (2013) specifically recommends fire management for the recovery of southwestern willow flycatcher (*Empidonax traillii extimus*) populations, which breed in habitats similar to those that GIFL use for foraging (and possibly nesting). In addition, the presence of flammable exotic species, such as grasses (e.g., buffelgrass [*Cenchrus ciliaris*]), may increase fire frequency and/or intensity in desert systems, destroying saguaro cacti (Bock and Block 2005; Corman 2005; Juarez 2010). 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 the grazing activity on riparian habitats along the LCR, which could affect GIFL or their habitat. Overgrazing by cattle (Bovidae), burros

(*Equus asinus*), or mule deer (*Odocoileus hemionus*) across the arid Southwestern United States has substantially degraded riparian habitat in many areas (see Appendix G *in* U.S. Fish and Wildlife Service 2002). (*Note*: Reclamation staff and researchers have observed mule deer and burros browsing on some LCR sites, which may affect vegetation communities if population numbers increase to the point that overgrazing occurs.) Grazing may thin the understory or even prevent the establishment of cottonwood and willow seedlings (Kauffman et al. 1997), affecting foraging habitat quality and the potential for future nest cavity trees should GIFL nest in riparian habitat. Overgrazing may remove upland grasses, reducing the seed supply for ants on which GIFL feed (B. Sabin and M.E. Chavez 2014, personal communication) and may impede ant foraging and nest construction (S. Cover 2014, personal communication). In heavily grazed grasslands in Nevada, western harvester ant (*Pogonomyrmex occidentalis* abundance declined, possibly due to soil compaction and/or to direct trampling of ant nests (Usnick and Hart 2002). In the case of GIFL, however, grazing by cattle, mule deer, or burros does not currently appear to have much impact in the LCR habitats in which GIFL occur (B. Sabin and B. Raulston 2019, personal communication).

NUISANCE SPECIES INTRODUCTION & 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 affect GIFL survival and reproduction. The nuisance species may infect, prey on, compete with, or present alternative food resources for GIFL during one or more life stages; cause other alterations to the riparian food web that affect GIFL; or affect physical habitat features such as vegetation cover. Exotic species, such as grasses, have increased wildfire frequency and intensity, with effects on preferred nesting sites in saguaro cacti (see “Fire Management,” above). Invasive saltcedar (*Tamarisk* sp.) has degraded riparian habitat generally in the LCR region, preventing germination and establishment of new cottonwood or willow trees. This may affect GIFL foraging as well as reduce the potential for suitable nesting sites in the future.

Although there is a red fire ant native to Arizona (southern fire ant, *Solenopsis xyloni*), of greater concern is the invasive red imported fire ant (*Solenopsis invictus*), which has not yet become established in Arizona. In other areas where this exotic ant species has spread and become established, it has been shown to

outcompete or consume smaller native ant species as well as negatively affect vertebrate wildlife (Global Invasive Species Database 2019), in particular acting as a nest predator.

Elchuk and Wiebe (2002) observed that northern flickers preferred to feed on less aggressive ant species and at smaller anthills; GIFL may have similar preferences. The displacement of preferred native ant species by introduced non-native ant species may affect the GIFL diet, altering its nutritional quality by reducing abundance and diversity of prey. In another ant-obligate species, the coastal horned lizard (*Phrynosoma coronatum*), growth rates were negative or near zero when fed only non-native Argentine ants (*Linepithema humile*); however, growth rates increased when fed a diet of native ants (Suarez and Case 2002).

Pesticide Application

The name and discussion of this controlling factor is updated as follows:

This factor addresses pesticide applications (e.g., herbicide, insecticide, fungicide, etc.) that may occur on, or adjacent to, riparian habitat along the LCR. Effects may include sublethal or lethal poisoning of GIFL via ingestion of treated insects and a reduced or modified invertebrate food supply. Any pesticide application that targets ant colonies or other ground-dwelling arthropods is particularly problematic, as flickers feed primarily on ants. In addition, herbicide treatment of cheatgrass (*Bromus tectorum*) that affects other grass species on which ants depend may be problematic (see “Nuisance Species Introduction & Management,” above).

Planting Regime

This controlling factor is updated as follows:

This factor addresses the active restoration program to restore cottonwood-willow riparian habitat along the LCR and includes both the community planted as well as the manner in which it is planted within restoration areas (e.g., density, age, and patch size). GIFL are known to forage in riparian habitats post-breeding and over the winter. They may also nest or roost in older cottonwoods or willows and often frequent mesquite shrub habitat (Hunter 1984; Sabin 2012; B. Sabin and M.E. Chavez 2014, personal communication).

SITE MANAGEMENT

No change.

WATER STORAGE-DELIVERY SYSTEM DESIGN & OPERATION

This controlling factor is updated as follows:

Riparian habitat that may be used by GIFL is along regulated waterways. The water moving through these systems is highly managed to allow for storage and delivery (diversion) to numerous international, Federal, State, Tribal, and municipal users and for hydropower generation and irrigation. Along the LCR, GIFL use riparian habitats for foraging and roosting (Best et al. 2015; GBBO 2011, 2012; Rosenberg et al. 1991; B. Sabin and M.E. Chavez 2014, personal communication), although there are past records of nesting in cottonwoods/willows (Reclamation 2016 and references therein; Rosenberg et al. 1991).

Updates to Chapter 6 – Conceptual Ecological Model by Life Stage

The following sections identify all changes made to the GIFL 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 effect on Food Availability (HE): Although not the main determinant of food availability (foraging habitat and plant species determine seed availability for seed eating ant species), high densities of grazing animals (depending on habitat and ant species) can reduce ant colony numbers by trampling nests or compacting soil, making nest construction difficult. The link is hypothesized to be negative and unidirectional, with low link intensity, low spatial scale, and low temporal scale. (Although grazing intensity can be high, occur over large areas and time scales, grazing by mule deer, burros, or cattle is not a concern on LCR lands supporting GIFL at this time. Also, GIFL will feed on other invertebrates and seeds/berries.) Overall link magnitude is low, with low predictability and low understanding. (The effect of grazers on ant populations in LCR is unstudied). *Applies to all life stages*.

- Planting Regime effect on Tree Cavities (HE): This link was originally included in the breeding adults life stage, and is now being added to the other three life stages, as the definition was broadened to include roost trees as well as nest cavity trees. The link interactions remain the same. The link is hypothesized to be positive and unidirectional, with medium link intensity, low spatial scale, and medium temporal scale. Overall link magnitude is medium, with low predictability and low understanding. *Applies to the eggs/nestlings, juveniles, and overwintering individuals life stages.*

- Water Storage-Delivery System Design & Operation effect on Tree Cavities (HE): This link was originally included in the breeding adults life stage, and is now being added to the other three life stages, as the definition was broadened to include roost trees as well as nest cavity trees. The link interactions remain the same. The link is hypothesized to be complex and unidirectional, with high link intensity, medium spatial, and medium temporal scale. Overall magnitude is medium, with low predictability and medium understanding. *Applies to the eggs/nestlings, juveniles, and overwintering individuals life stages.*

- Fire Management effect on Tree Cavities (HE): This link was originally included in the breeding adults life stage, and is now being added to the other three life stages, as the definition was broadened to include roost trees as well as nest cavity trees. The link interactions remain the same. The link is hypothesized to be complex and unidirectional, with high link intensity, high spatial scale, and medium temporal scale. Overall link magnitude is high, with medium predictability and high understanding. *Applies to the eggs/nestlings, juveniles, and overwintering individuals life stages.*

- Nuisance Species Introduction & Management effect on Tree Cavities (HE): This link was originally included in the breeding adults life stage. and is now being added to the other three life stages. as the definition was broadened to include roost trees as well as nest cavity trees. The link interactions remain the same. The link is hypothesized to be complex and unidirectional, with high link intensity, high spatial scale, and high temporal scale. Overall link magnitude is high, with low predictability and medium understanding. *Applies to the eggs/nestlings, juveniles, and overwintering individuals life stages.*

- Grazing effect on Tree Cavities (HE): This link was originally included in the breeding adults life stage, and is now being added to the other three life stages, as the definition was broadened to include roost trees as well as nest cavity trees. The original link was considered to be negative and unidirectional, with high intensity, medium spatial scale, and medium temporal scale, as grazing cattle eat young saguaro cacti as well as riparian tree species, and trampling may destroy seedlings. However, grazing (by mule deer, burros, or cattle) is not a concern on LCR sites being used by or managed for GIFL at this time. Therefore, the values have been modified in this update. The link remains negative and unidirectional; however, link intensity is low, spatial scale low, and temporal scale low. Overall link magnitude is low, link predictability remains medium, and link understanding remains high. *Applies to the eggs/nestlings, juveniles, and overwintering individuals life stages.*

DELETED LINKS WITH CONTROLLING FACTORS AS CAUSAL AGENTS

No change.

UPDATED LINKS WITH CONTROLLING FACTORS AS CAUSAL AGENTS

- Grazing effect on Foraging Habitat (HE): The original link was considered to be complex and unidirectional, with high link intensity, high spatial scale, and low temporal scale, as grazing can have great effects on vegetation by trampling and consumption of vegetation, and it is often implemented over large areas and long time scales. However, grazing (by mule deer, burros, or cattle) is not a concern on LCR sites being used by or managed for GIFL at this time. Therefore, the values have been modified in this update. The link remains complex and unidirectional; however, link intensity is low, spatial scale is low, and temporal scale is low. Overall link magnitude is low; link predictability remains medium, and link understanding remains high. *Applies to all life stages.*

- Grazing effect on Tree Cavities (HE): The original link was considered to be negative and unidirectional, with high link intensity, medium spatial scale, and medium temporal scale, as grazing cattle eat young saguaro cacti as well as riparian tree species, and trampling may destroy seedlings. However, grazing (by mule deer, burros, or cattle) is not a concern on LCR sites being used by or managed for GIFL at this time. Therefore, the values have been modified in this update. The link remains negative and unidirectional; however, link intensity is low, spatial scale is low, and temporal scale is low. Overall link magnitude is low; link predictability remains medium, and link understanding remains high. *Applies to the breeding adults life stage.*

- Nuisance Species Introduction & Management effect on Nest Cavity Competitors (HE): Starlings are the primary nest competitor considered in this model. The link is hypothesized to be positive (more introductions, more competitors [starlings] in a habitat) and unidirectional, with proposed low link intensity, low spatial scale, and high temporal scale. Overall link magnitude is medium, with low predictability and medium understanding. *Applies to the breeding adults life stage.*

- Nuisance Species Introduction & Management effect on Nest Predators (HE): The original link was between nuisance species introduction & management and predators; however, Predators has been renamed Nest Predators in the eggs/nestlings life stage. All link interactions remain the same. Nuisance species introductions can increase the number and diversity of potential nest predators. The link is hypothesized to be complex (more introductions, more potential predators; however, interactions with existing community unknown) and unidirectional, with proposed medium intensity, unknown spatial scale, and high temporal scale (introduced species often remain in the landscape once they become established); low predictability (usually species introductions are not intentional and cannot be predicted); and low understanding (there remains much to learn about nuisance species and effects on ecosystems, including predator species assemblage). *Applies to the eggs/nestlings life stage*.

New Links with Habitat Elements as Causal Agents

- Anthropogenic Disturbance effect on Nest Site Selection (CAP): GIFL tend to avoid nesting in urban areas, selecting saguaro cacti cavities in desert scrub habitats away from development. The link is hypothesized to be negative and unidirectional (more human development, less likelihood of nesting even if habitat appears suitable) with medium link intensity, low spatial scale, and low temporal scale. Overall link magnitude is low, with low predictability (many factors affect nest site location) and low understanding (more research needed on disturbance effects on GIFL in LCR). *Applies to the breeding adults life stage*.

- Nest Cavity Competitors effect on Nest Cavity Competition (CAP): Starlings can be an important nest competitor, especially in habitats that are cavity limited. However, they are not abundant in the LCR in habitats used by GIFL. For this reason, the link is hypothesized to be positive (more competitors, more competition) and unidirectional, with proposed low link intensity, low spatial scale, and low temporal scale. Overall link magnitude is low, with low predictability and low understanding. *Applies to the breeding adults life stage.*

- Genetic Diversity effect on Disease (CAP): Genetic Diversity is a new habitat element. Genetic diversity does affect disease susceptibility; however, although there are concerns about habitat loss and fragmentation effects on saguaro habitats preferred by GIFL, there is no information about the genetic diversity of GIFL in the LCR. The link is hypothesized to be complex and unidirectional, with low link intensity, low spatial scale, and low temporal scale low. Overall link magnitude is low, with low predictability and low understanding. *Applies to all life stages.*

Deleted Links with Habitat Elements as Causal Agents

- Temperature effect on Thermal Stress (CAP): The link in the overwintering individuals life stage has been removed, as there is no indication that temperatures during this time period cause thermal stress. As defined in the model, most concern is related to high summer temperatures and the effects on thermal stress of eggs/nestlings, juveniles, and breeding adults. *Applies to the overwintering individuals life stage.*

Updated Links with Habitat Elements as Causal Agents

- Nest Predators effect on Nest Predation (CAP): In the original model, the link was between predators and predation; however, for the eggs/nestlings life stage, Predators has been renamed Nest Predators, and Predation has been renamed Nest Predation. All link interactions remain the same. Nest predators often differ from predators of adults, and there is often more information available about them. Other bird models have separated predation at the eggs/nestlings life stage from adult predation, and this update will make the GIFL model consistent with other models. The link is hypothesized to be positive (more predators, greater likelihood of predation) and unidirectional, with proposed medium intensity, medium spatial scale, and medium temporal scale. Overall link magnitude is medium, with medium predictability and medium understanding. (Other factors affect predation rates, and rates of predation of GIFL have not been studied on the LCR). *Applies to the eggs/nestlings life stage*.

- Foraging Habitat effect on Nest Predators (HE): In the original model, the link was between foraging habitat and predators; however, for the eggs/nestlings life stage, Predators has been renamed Nest Predators. All link interactions remain the same. *Applies to the eggs/nestlings life stage.*

- Predators effect on Predation (CAP): The Predators/Competitors habitat element has been renamed and redefined as Predators – competition has been removed from all link reasons. All link interactions remain the same. *Applies to the juveniles, overwintering individuals, and breeding adults life stages.*

- Parental Care effect on Nest Predation (CAP): The Parental Feeding Behavior and Parental Nest Attendance habitat elements have been combined and renamed Parental Care, while Predation has been renamed Nest Predation. This link replaces the old Parental Nest Attendance link to Predation. All link interactions and reasons remain the same. *Applies only to the eggs/nestlings life stage.*

- Temperature effect on Thermal Stress (CAP): The link character was changed to positive; character reason changed. Higher temperatures may increase thermal stress. All other link interactions and reasons remain the same. *Applies to the eggs/nestlings, juveniles, and breeding adults life stages.*

- Brood/Litter Size effect on Nest Attendance (CAP): The link character direction has been changed from bi-directional to unidirectional. (The bigger the brood, the more demand is placed on the parents to provision young.) However, there is a threshold placed on the birds by foraging ability and food availability. *Applies to the breeding adults life stage.*

New Links with Critical Activities/ Processes as Causal Agents

- Nest Cavity Competition effect on Nest Site Selection (CAP): Starlings can be a significant nest competitor, especially in habitats that are cavity limited, deterring other birds from nesting. However, because starlings are not abundant in the LCR habitats used by GIFL, the interaction strengths are considered low. The link is hypothesized to be negative (more competition, less options for nest site selection) and unidirectional, with proposed unknown link intensity, low spatial scale, and low temporal scale (effect will be during nesting season and at a patch size; unknown if starlings affect GIFL to the same extent as they do some other woodpecker

species). Overall link magnitude is low, with low predictability and low understanding (starling densities vary in space and time; more research is needed on starling effects on GIFL in LCR). *Applies to the breeding adults life stage.*

Deleted Links with Critical Activities/ Processes as Causal Agents

- Thermal Stress effect on Overwintering Individual Survival (LSO): The link in the overwintering individuals life stage has been removed, as there is no indication that temperatures during this time period cause thermal stress that affects GIFL survival. As defined in the model, most concern is related to high summer temperatures and effects on thermal stress of eggs/nestlings, juveniles, and breeding adults. *Applies to the overwintering individuals life stage.*

- Nest Site Selection effect on Thermal Stress (CAP): This link has been removed for continuity with other bird models. *Applies to the breeding adults life stage.*

Updated Links with Critical Activities/ Processes as Causal Agents

- Nest Predation effect on Egg/Nestling Survival (LSO): The original link was between Predation and Survival; however, for the eggs/nestlings life stage, Predation has been renamed Nest Predation. All link interactions remain the same. Nest predation will reduce survival. Young likely are more vulnerable to predation than adults. The link is hypothesized to be negative (predation usually results in death of individual) and unidirectional, with proposed high intensity, low spatial scale, and low temporal scale. Overall link magnitude is low, with low predictability and low understanding, as it is difficult to know what predators will be at a site, and impacts of predation on GIFL along the LCR have not been well studied. *Applies to the eggs/nestlings life stage.*

- Disease effect on Foraging (CAP): The original link understanding was considered to be unknown. The model now proposes the link understanding to be low for consistency among models. The link understanding reason has been updated. All other link values remain the same. *Applies to the breeding adults life stage.*

- Disease effect on Nest Attendance (CAP): The original link understanding was considered to be unknown. The model now proposes the link understanding to be low for consistency among models. The link understanding reason has been updated. All other link values remain the same. *Applies to the breeding adults life stage.*

- Disease effect on Molting (CAP): The original link understanding was considered to be unknown. The model now proposes the link understanding to be low for consistency among models. The link understanding reason has been updated. All other link values remain the same. *Applies to the breeding adults life stage.*

- Disease effect on Thermal Stress (CAP): The character type has been changed to positive, and the direction is now bi-directional. The reason has been revised. Disease may increase physiological vulnerability to thermal stress and vice versa. All other link values and reasons remain the same. *Applies to all life stages.*

- Thermal Stress effect on Survival (LSO): The character type has been changed to negative, and the reason has been revised. Increasing thermal stress may reduce survival. All other link values and reasons remain the same. *Applies to the eggs/nestlings, juveniles, and breeding adults life stages.*

New Links with Life-Stage Outcomes as Causal Agents

No change.

SUMMARY OF STANDARDIZATION OF TERMS

Table 5.—(New table for this update) Updated GIFL conceptual ecological model component names
(Blue indicates new or revised items; orange indicates replaced items. Italicized entries are explanatory comments.)

GIFL conceptual ecological model updated terms, 2019	GIFL conceptual ecological model original terms, 2015–16
Life Stages	
Eggs/Nestlings (*renamed*)	Nest
Juveniles (*renamed*)	Juvenile
Overwintering Individuals (*renamed*)	Overwintering Individual
Breeding Adults (*renamed*)	Breeding Adult
Life-Stage Outcomes	
Egg/Nestling Survival (*renamed*)	Survivors
Juvenile Survival (*renamed*)	
Overwintering Individual Survival (*renamed*)	
Adult Fertility (*renamed*)	GIFL Reproductive Output
Adult Survival (*renamed*)	GIFL Survival
	Offspring
Critical Biological Activities and Processes	
Nest Cavity Competition (*renamed*)	Competition
Disease	Disease
Eating	Eating
Foraging	Foraging
Molting (*renamed*)	Molt
Nest Attendance	Nest Attendance
Nest Predation (*new*)	
Nest Site Selection	Nest Site Selection
Predation	Predation
Thermal Stress (*renamed*)	Temperature Regulation
Habitat Elements	
Anthropogenic Disturbance (*new*)	
Brood/Litter Size (*renamed*)	Brood Size
Food Availability	Food Availability
Foraging Habitat	Foraging Habitat
Genetic Diversity (*new*)	
Infectious Agents	Infectious Agents
Parental Care (*renamed*)	Parental Feeding Behavior
	Parental Nest Attendance
Predators (*renamed*)	Predator/Competitor Density
Nest Predators (*new*)	
Nest Cavity Competitors (new) (split from Predator/ Competitor Density	
Temperature	Temperature
Tree Cavities	Cavity Trees
Controlling Factors	
Fire Management	Fire Management
Grazing	Grazing
Nuisance Species Introduction & Management	Nuisance Species Introduction and Management
Pesticide Application (*renamed*)	Pesticide/Herbicide Application
Planting Regime	Planting Regime
Site Management	Site Management
Water Storage-Delivery System Design & Operation	Water Storage-Delivery System Design and Operation

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ACKNOWLEDGMENTS

The authors of the original GIFL conceptual ecological model in 2015 acknowledged Eric Best, Mary Ellen Chavez, and Beth Sabin, biologists with the LCR MSCP; Sonja Kokos, Adaptive Management Group Manager, 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 update acknowledge additional invaluable technical feedback from Joseph Kahl, Jr., Barbara Raulston, Carolyn Ronning, and Beth Sabin, LCR MSCP; Becky Blasius, Adaptive Management Specialist, LCR MSCP; and Jimmy Knowles, Adaptive Management Group Manager, LCR MSCP.

ATTACHMENT 1

Gilded Flicker (*Colaptes chrysoides*) (GIFL) Habitat Data

Table 1-1.—Gilded flicker (*Colaptes chrysoides*) (GIFL) habitat data
(Note: This is an update of Table 2.1 found in Attachment 2 of the original GIFL conceptual ecological model document.
* The data presented in this table reflect those available in the literature at the time this model was developed. These data have not been validated. There are no data available about typical habitat variables such as canopy cover, patch size, tree density, etc. More research is needed to better describe habitat parameters for GIFL.)

Habitat element	Value or range	Location	Reference
Brood/litter size	Typically 3–5 eggs laid	Rangewide and lower Colorado River	Best et al. 2017; Koenig 1984
Tree cavities	Saguaro cacti (*Carnegiea gigantea*), cottonwoods (*Populus fremontii*), willows (*Salix* sp.), and honey mesquite (*Prosopis glandulosa*)	Lower Colorado River	Bureau of Reclamation 2008, 2016
	Nest cacti > 5 meters tall	Lower Colorado River	Kerpez and Smith 1990
	Will use Joshua trees (*Yucca brevifolia*) and other yuccas	Southern Nevada and northwestern Arizona	Floyd et al. 2007; B. Raulston 2019
Food availability	Diet consists of ants and ant larvae, ground beetles, and other soil invertebrates; seeds, berries, and cacti fruits	United States – general diet for flickers; lower Colorado River	Best et al. 2017; Bureau of Reclamation 2008, 2016 and references therein
Foraging habitat	Includes open areas, friable soil for ants, flowering shrubs that attract insects, and seeds and berries	Lower Colorado River	Best et al. 2015; Sabin 2018, personal communication; Sabin and Chavez 2014, personal communication
	Includes ocotillo (*Fouquieria splendens*), palo verde (*Parkinsonia florida*), and ironwood (*Olneya*)	Lower Colorado River	Kerpez and Smith 1990; Sabin and Chavez 2014, personal communication
	Includes Joshua tree habitats	Southern Nevada and northwestern Arizona	Floyd et al. 2007
Genetic diversity	No quantifiable values found in literature		
Infectious agents	No quantifiable values found in literature		
Nest cavity competitors	European starlings (*Sturnus vulgaris*) compete for nest cavities with other woodpeckers, possibly GIFL		Bureau of Reclamation 2016; Kerpez and Smith 1990
Nest predators	Gophersnakes (*Pituophis catenifer*)		Bent 1939
Parental care	No quantifiable values found in literature		
Predators	Species lists available		
Temperature	July temperatures outside saguaro cactus 46 °C	Quartzite, Arizona	Best et al. 2017

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