Science and Adaptive Management Committee Meeting

December 7, 2020

Meeting Materials:

Agenda

Minutes

Draft MRGESCP 2021 Objectives Workshop: Pre-Workshop Survey [read-ahead, draft]

Draft MRGESCP S&T Ad Hoc Group Charge Template [read-ahead, draft]

Species CEMs (Appendices B and C from S&AM Plan) [read-ahead]

Consolidated Caplan, Noon, Hubert, and Fraser Panel Recommendations [read-ahead, spreadsheet]

Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Science and Adaptive Management Committee (SAMC) Meeting
December 7, 2020
9:00 AM–12:00 PM

Meeting Location: *Zoom*
https://west-inc.zoom.us/j/8983593120?pwd=bU54V3NGeG93bXVlSlJFcEIzcE9wZz09
Meeting ID: 898-359-3120; Passcode: 1251
Call-In: +1-669-900-6833

Meeting Agenda

9:00 – 9:10	**Welcome and Agenda Review** Read-ahead: ☐ November 13, 2020 SAMC draft meeting minutes ✓ **Decision**: Approval of December 7, 2020 SAMC meeting ✓ **Decision**: Approval of November 13, 2020 SAMC meeting minutes	*Catherine Murphy, Program Support Team*
9:10 – 10:30	**Discuss Objectives Workshop** • Workshop timing: late January/early February 2021 • Review pre-workshop survey questions • Discuss workshop format and facilitation • Discuss call for participation Read-ahead: ☐ Pre-workshop survey ✓ **Decision**: Workshop format and sessions ➢ **Action Item**: PST will distribute pre-workshop survey to Program participants and compile results ➢ **Action Item**: PST will schedule objectives workshop	*Facilitated discussion*
10:30 – 10:40	**Break**	
10:40 –11:10	**Discuss Science & Technical (S&T) Ad Hoc Group charges** • Designing S.M.A.R.T. charges • Incorporating uncertainty into deliverables Read-ahead: ☐ S&T Ad Hoc Group charge template ✓ **Decision:** Approval of S&T Ad Hoc Group charge template	*Facilitated discussion*

11:10 – 11:40	**Discuss Adaptive Management (AM) Database**
	• Representing critical uncertainties
	  o Conceptual ecological models (CEMs)
	  o Independent Science Panel recommendations
	  o Linking to other elements
	
	Read-aheads:
	☐ Species CEMs (Appendices B and C from Science & AM Plan)
	☐ Consolidated panel recommendations table
	☐ Link to Shay Howlin presentation on AM Database
		Facilitated discussion

11:40 –12:00	**Meeting Summary and Action Items Review** ➢ **Next Meeting**: January 2021	
12:00	**Adjourn**	

Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Science and Adaptive Management Committee (SAMC)
Meeting Minutes

December 7, 2020; 9:00 AM–12:00 PM
Location: Zoom Meeting

Decisions:
- ✓ Approval of the November 13, 2020 SAMC meeting minutes
- ✓ Approval of the December 7, 2020 SAMC meeting agenda

Action Items:

WHO	ACTION ITEM	BY WHEN
Program Support Team (PST)	Send out Doodle Polls to schedule the next SAMC meeting and Objectives Workshop	12/7/2020
Megan Friggens	Send information on uncertainty to Catherine Murphy	12/7/2020
Michelle Tuineau, PST	Create a SAMC Work Page on the Program Portal	By next meeting
Catherine M.	Revise the pre-workshop survey and Science & Technical (S&T) Ad Hoc Group charge template and send them to the SAMC	12/11/2020
SAMC	Send feedback on the pre-workshop survey and S&T Ad Hoc Group charge template to Catherine M.	12/16/2020
Catherine M.	Discuss the pre-workshop survey and S&T Ad Hoc Group charge template during the SAMC update at the Executive Committee (EC) meeting	12/17/2020
PST	Distribute pre-workshop survey to Collaborative Program members and collect responses	1/21/2021
Thomas Archdeacon	Send Rio Grande Silvery Minnow (RGSM) rescue data to the PST for upload to the Program Portal	1/31/2021
Catherine M. & Shay Howlin	Populate the AM Database with the goals, objectives, and strategies, and build linkages between them	Ongoing
SAMC members	Provide suggestions to the PST for additional layers, and/or links to additional map tools and resources to include on the Portal	Ongoing

Next Meeting: January 2021

Meeting Summary

Welcome and Agenda Review

Catherine M., PST Science Coordinator and SAMC Facilitator, opened the meeting and led introductions. Catherine reviewed the November 13, 2020 minutes and December 7, 2020 agenda.

- ✓ **Decision**: The SAMC approved the November 13, 2020 SAMC meeting minutes
- ✓ **Decision**: The SAMC approved the December 7, 2020 SAMC meeting agenda

What Management Tools do the Signatories Have?

- A list of management tools needs to be incorporated into the Adaptive Management (AM) Database.
- It would be useful to talk to hydrologists at the U.S. Bureau of Reclamation (Reclamation) to get a better understanding of the tools.
- It is difficult to do altered water operations, like pulse releases. A big reason for this is the limited management flexibility around Cochiti Reservoir releases. The SAMC need to understand what the parameters are for releases at Cochiti Reservoir.
  - Cochiti Reservoir is authorized to hold San Juan Chama water at 12,000 surface acres; it is operated solely for flood control outside of that. There is no conservation storage or flexibility.
  - There is potential opportunity to manage Cochiti differently, but it takes an act of Congress to gain flexibility.
- The SAMC needs to think outside the box to modify management within constraints.
  - The water managers in the Collaborative Program have been enhancing the spring hydrograph without Cochiti through modifications at El Vado Reservoir, which is authorized to hold varying levels of water, unlike Cochiti Reservoir.
- The Minnow Action Team (MAT) discusses water operations. It would be good to bring in members like Carolyn Donnelly, Reclamation, and Nabil Shafike, U.S. Army Corps of Engineers (USACE), to describe the existing and potential tools available.
  - The MAT meetings are productive, but based on things happening that year. To improve long-term planning, it would be helpful to know the management parameters.
  - The SAMC needs to access the knowledge in the MAT, and the SAMC should help the MAT make more informed decisions.

Discuss Objectives Workshop

Catherine M. opened discussion on the Objectives Workshop by reviewing the pre-workshop survey (see survey). These were the main points of the discussion:

- Under the new Science & Adaptive Management Plan (S&AM Plan), the Program will use a hierarchical planning approach. This incorporates the strategic planning pyramid, so that goals (at the top) lead to objectives, which lead to strategies.
  - Everything ties back to the mission statement, to which the goals, objectives, and strategies should be linked. As the Program is operating under an adaptive management framework, the mission may be revised over time to better reflect Program operations and direction. If necessary, the SAMC will suggest revisions to the EC.
- The draft objectives included in the S&AM Plan appendix need to be revised to include measurable targets. Then, strategies to meet those measurable targets need to be developed.

- The survey will be translated to a Google Form, so people can easily give feedback on each objective and strategy.
- Who is able to attend the Objectives Workshop?
  - The workshop is open to the entire Collaborative Program.
  - Although there is no plan to limit the number of people at the workshop, the survey will give people a chance to contribute to the workshop without attending the workshop.
- Survey responses will be given on the Likert scale, which gives the SAMC qualitative data to analyze with sufficient responses, and allows for comparisons across years as the Program revises existing objectives, adopts new objectives, and completes objectives.
- Respondents will evaluate the objectives based on whether they align with the mission statement, support one or more goals, satisfy the definition of a S.M.A.R.T. (Specific, Measurable, Attainable, Relevant, Time-Bound) statement, and are a priority in the short term (five years).
- The challenge will be making the draft objectives measurable.
  - The survey will help identify objectives for which there is less agreement and/or that do not meet the S.M.A.R.T. requirements, so the Collaborative Program can focus in on them at the Objectives Workshop.
- The survey should include a space for people to comment or suggest changes.
- The objectives were written to tie into the recovery plans. There have been mixed feelings on this. As long as it is made clear that the Collaborative Program has no authority, it should be fine to connect objectives to recovery criteria.
- Catherine M. will discuss the survey at the next EC meeting before sending it out to the Collaborative Program.
- The Objectives Workshop will be scheduled for early February.
  - There will be two sessions: one focused on RGSM, and one on avian and other species
  - If needed, another Objectives Workshop can be scheduled.
- The objectives are heavily weighted toward biology, especially with the RGSM. There is not a lot mentioned on geomorphology or hydrology (water budget or status of gages). It would be good to emphasize those factors as well.
  - The objectives do not link to the panel recommendations, which would be a useful linkage to have. Some of the recommendations tee off each other, and the SAMC should try to preserve that information.
- There are a lot of objectives for the RGSM that could benefit the birds and other species, but those crosswalks aren't explored.

Other Questions:

Incorporating the Objectives into the AM Database

- All of the draft objectives and strategies will be in the AM Database. The objectives and strategies will be edited after the Objectives Workshop.
- Catherine will be working with Shay Howlin, PST, to connect the mission to the goals, the goals to the objectives, and the objectives to the strategies, in the AM Database.
  - Once projects are linked to strategies, they will have a pathway back to the objectives, goals, and mission.
- When sorting through the Project Bank, users can query to find out what objectives and goals each project connects to. This can be a powerful management tool.

Representing Uncertainty

- With regards to research, should the reduction of critical uncertainties be represented via relational pathways from the conceptual ecological models (CEMs) to uncertainties to hypotheses to projects?
    - This can be difficult with older projects as their descriptions are vague, and it is almost impossible to determine their research hypotheses.
    - The CEMs need work, but can be refined with this goal in mind.
    - There may be other ways to categorize research, as a lot of things don't fit into this format. The SAMC should explore other options.
    - Although old descriptions cannot be changed, new information can be collected through a form with the specific fields needed. That way, projects can be entered into the Project Bank pre-formatted.
- The independent science panel recommendations are the other source of uncertainties.
    - Catherine M. noted that the Program has funded three panel reports in the past five years which have not been addressed fully, and recommended that the Program focus on those before contracting out any new panels.
    - The SAMC will decide how to prioritize recommendations and S&T Ad Hoc Groups to work on them.
    - Some recommendations have been addressed, but there is not currently a way to show that.

- **Action Item**: The PST will send out a Doodle Poll to schedule the Objectives Workshop during the first two weeks of February
- **Action Item**: Catherine Murphy will revise the pre-workshop survey and send it to the SAMC
- **Action Item**: The SAMC will send feedback on the pre-workshop survey to Catherine Murphy
- **Action Item**: Catherine Murphy will discuss the pre-workshop survey during the SAMC update at the EC meeting
- **Action Item**: The PST will distribute the pre-workshop survey to Collaborative Program participants and collect responses
- **Action Item**: Catherine Murphy and Shay Howlin will populate the AM Database with goals, objectives, and strategies, and build linkages

Discuss Science & Technical (S&T) Ad Hoc Group charges

Catherine M. opened discussion on the S&T Ad Hoc Group charge template (see template). These were the main points of the discussion:

- The SAMC will come up with member lists and alternates with the help of the PST.
- The most important thing is coming up with the right questions to ask. Charges should be specific and measurable, with a deadline. They should be small enough to complete in the time frame.
- Catherine can come up with draft charges for SAMC review and revision.
- How is membership determined?
    - The SAMC will come up with the question first, then choose people who can best accomplish the work.
- What is the preferred size for groups?
    - Group size will vary, but should be no more than 10. 5-person groups are typically productive.
- The first S&T Ad Hoc Groups formed will likely be to address Population Monitoring Work Group (PMWG) tasks.

    - The PMWG is drafting a report for the EC. The report condenses down the group's work into a list of findings and list of recommendations.
- If the SAMC outlines the tasks for the S&T Ad Hoc Groups, that might be an unnecessary level of micro managing. Instead, there could be an iterative process, whereby the SAMC gives the group a question, the group develops an approach to answer the question, and the SAMC reviews the approach and refines it, if necessary, ensuring it aligns with the Collaborative Program's guiding principles.
    - The most important part of forming these ad hoc groups is narrowing the scope of each question, so a group fully understands its charge.
- Concerning the process for making up the S&T Ad Hoc Groups:
    - S&T Ad Hoc Groups will be formed to complete outstanding tasks from the PMWG, as determined by the SAMC.
    - Should the long-standing groups be asked to determine objectives and tasks for S&T Ad Hoc Groups?
        - Catherine is working with the PMWG to present to the SAMC by the end of the year to inform SAMC deliberations and decisions on how work should move forward.
    - Past group objectives have not been S.M.A.R.T. How does the SAMC ensure they are?
        - An iterative approach allows the SAMC to approve only S.M.A.R.T. objectives.
    - Other S&T Ad Hoc Groups will be formed by the SAMC from the list of members that participated in previous standing work groups, including the genetics group.

- **Action Item**: Catherine Murphy will revise the S&T Ad Hoc Group charge template and send it to the SAMC
- **Action Item**: The SAMC will send feedback on the S&T Ad Hoc Group charge template to Catherine Murphy
- **Action Item**: Catherine Murphy will discuss the S&T Ad Hoc Group charge template during the SAMC update at the EC meeting
- **Action Item**: Catherine Murphy will work with the PMWG chair for a presentation to the SAMC

Discuss Adaptive Management (AM) Database

Catherine M. opened discussion on the AM Database. These were the main points of the discussion:

- The CEMs are in different formats and stages of development. The SAMC needs to form S&T Ad Hoc Groups to fit them into the AM Database.
- The main difference between the avian and RGSM CEMs is how much basic life history is missing for the birds.
- The SAMC has to determine how to capture uncertainty in the CEMs and determine which uncertainties are reducible and which are not.
    - The SAMC needs to characterize data variability and report estimation error and bias.
- Shay H. and a WEST team are adding the relational links to the information in the AM Database.
    - The team is developing a user interface.
- Users will be able to generate summary reports.
- Suggestion to add a flowchart that depicts relationships in the database.

Prioritizing Uncertainties

- The SAMC needs to prioritize uncertainties from the CEMs and independent science panels.

- The SAMC decided to integrate the panel recommendations into the CEMs. They will find out where there is overlap or redundancy, produce one list of uncertainties, and use the top-down approach from the guiding principles to prioritize them.
- Have CEMs for the listed species been developed by other groups (outside MRG)?
    - There are other CEMs for the birds and RGSM, but they were not agreed upon for development of the Collaborative Program CEMs.
    - The Collaborative Program CEMs were agreed upon, but are meant to be iterative and changed to reflect current state of understanding about the life history, biology, and ecosystem relationships for each species.
- The Collaborative Program may need to produce two versions of each CEM depicting different levels of detail for different audiences: one that is an overview for managers and the public, and one more detailed for technical experts.
- There are a lot of assumptions built into CEMs that need to be explicitly stated.
    - Is there a way to represent those assumptions in the CEM?
        - Megan F. will send a presentation on uncertainty and vulnerability assessments; it discusses how to qualitatively and quantitatively describe uncertainty.
- Is there a document where the CEMs are laid out?
    - They are in an appendix of the Science & AM Plan.
    - Uncertainty in relationships is currently represented through color-coding.
- With the information currently available on the RGSM, contradictory hypotheses could be developed.
    - The supporting evidence for each hypothesis needs to be presented in a transparent manner.
- Managers need to know the uncertainty associated with their decisions. The SAMC needs to find a way to present what is not known and where there is disagreement based on different studies.
- Uncertainty should be incorporated into the S&T Ad Hoc Group charges. The groups will be asked to characterize the uncertainty and assumptions linked to their work products.

➢ **Action Item**: Megan Friggens will send information on uncertainty to Catherine Murphy

Long-Term Plan

- The Long-Term Plan (LTP) being developed is meant to help USACE secure funding. It will be updated next year to incorporate elements laid out in the S&AM Plan, such as newly adopted objectives and strategies and links to a list of prioritized projects, so it will be a more effective tool for both Program and signatory planning efforts.
- How should climate trends and forecasts be incorporated into the prioritization process for the projects?
    - The form to submit a project to the AM Database could include a question about climate change.
    - The form could also ask if an activity relates to the resilience/resistance transition, which is popular in AM strategies for climate change.

Other Topics

Cross-Disciplinary Communication

- How should the SAMC get managers, engineers, scientists, etc. speaking the same language?
    - You have to create projects that integrate different disciplines and force everyone to listen to each other.

    - Any activity that drives empathy and makes people see from other points of view helps communication.
- Reclamation is in the process of starting a width maintenance program that has the potential to link benefits among species.
    - In the Los Lunas area, there is a decrease of conveyance capacity in the active channel. Reclamation wants to increase capacity by removing vegetated islands and bars.
    - Reclamation has to differentiate between good habitat and habitat that has outgrown its effectiveness in order to optimize river widening for bird and RGSM habitat.
    - Reclamation wants to create a program that gets updated every year.
    - It will be a collaborative project between U.S. Fish and Wildlife Service (USFWS), USACE, New Mexico State, and others.
    - There is an opportunity for the Collaborative Program to help inform decisions.
- There are projects going on that can serve as examples for how the Collaborative Program can optimize activities. The SAMC should keep an eye out for examples.

Interactive Mapper

- Alyssa O'Brien, City of Albuquerque, Open Space Division, asked if the SAMC wanted to add a layer to the interactive mapper on the Portal that shows all the work being done in the system.
- A riparian vegetation map for the whole state is being developed and the layer is available for download.
- The fish release data from Thomas A., USFWS, can be added to the Portal.
- The SAMC should send any suggestions for layers to add to the mapper.
- If layers cannot be added, links to other map tools and resources can be provided via the Portal.

➢ **Action Item**: PST will upload fish release data to the Program Portal
➢ **Action Item**: SAMC members will provide suggestions to the PST for additional layers, and/or links to additional map tools and resources to include on the Portal

Closing Discussions

- Earlier, the SAMC discussed bringing in managers to present on the management tools they have.
    - Managers may be hesitant to tell the SAMC. Also, management tools change in response to conditions every year.
    - The SAMC may want to work with the MAT to get that information.
    - The SAMC has a lot of other activities to get through before reaching out to managers.
- Michelle T. looked into adding a platform for SAMC collaboration on the Portal.
    - Funding is limited, as the contract with U.S. Geological Survey (USGS) ends soon.
    - USGS can produce a password-protected page for SAMC documents. The PST will have to upload all documents.
    - A chat or forum function can be added if funding for development continues next year.

➢ **Action Item**: Michelle Tuineau will create a SAMC Work Page on the Portal

Announcement

- Cliff Dahm, one of the keynote speakers at the 2020 Science Symposium, has a lot of experience bridging science and management. He is willing to attend a SAMC meeting to speak on his experiences.

Meeting Participants

EC *Ex Officio* Member	Alan Hatch
Statistics/Modeling Expert	Ara Winter
Geomorphology Expert	Ari Posner
PST Science Coordinator and SAMC Facilitator	Catherine Murphy
Terrestrial Ecology Expert	David Moore
Ecosystem Function Expert	Meaghan Conway
Climate Science Expert	Megan Friggens
PST Project Coordinator	Michelle Tuineau
Aquatic Ecology Expert	Mo Hobbs
Hydrology Expert	Ryan Gronewold
Aquatic Ecology Expert	Thomas Archdeacon

MRGESCP SCIENCE AND ADAPTIVE MANAGEMENT COMMITTEE

JANUARY XX, 2021 OBJECTIVES WORKSHOP: PRE-WORKSHOP SURVEY

PURPOSE

The purposes of the objectives workshop are **1)** to align the Collaborative Program's planning objectives with its mission statement and goals and **2)** to appraise the objectives and associated strategies yearly with input from stakeholders and technical experts.

MRGESCP MISSION STATEMENT

The Middle Rio Grande Endangered Species Collaborative Program provides a collaborative forum to support scientific analysis and implementation of adaptive management to the benefit and recovery of the listed species pursuant to the Endangered Species Act within the Program Area, and to protect existing and future water uses while complying with applicable state, federal and tribal laws, rules, and regulations.

MRGESCP SPECIES

The Collaborative Program currently aids in the recovery of five species listed under the Endangered Species Act (ESA):

- ✓ Endangered Rio Grande silvery minnow (*Hybognathus amarus*; RGSM);
- ✓ Endangered southwestern willow flycatcher (*Empidonax traillii extimus*; SWFL);
- ✓ Endangered New Mexico meadow jumping mouse (*Zapus hudsonius luteus*; NMMJM);
- ✓ Threatened yellow-billed cuckoo (*Coccyzus americanus*; YBCU); and
- ✓ Threatened Pecos sunflower (*Helianthus paradoxus*; PESU).

MRGESCP Goals

- ➢ Establish and maintain a self-sustaining population of endangered RGSM distributed throughout the MRG.
- ➢ Maintain and protect the MRG recovery unit goals for endangered SWFL.
- ➢ Maintain and protect suitable threatened YBCU habitat in the MRG.
- ➢ Establish and maintain a self-sustaining endangered NMMJM population in the MRG.
- ➢ Maintain and protect the threatened PESU in the MRG.
- ➢ Avoid the future listing or up-listing of species in the MRGESCP area.
- ➢ Manage available water to meet the needs of endangered species and their habitat.

Designing S.M.A.R.T. Objectives

- ☐ **S**pecific – provide sufficient detail to pinpoint problems and opportunities
- ☐ **M**easureable – create a metric to quantify success
- ☐ **A**ttainable – define an objective that is challenging, but possible
- ☐ **R**elevant – ensure that the objective applies to a real-world problem
- ☐ **T**ime-bound – set a reasonable deadline

Pre-Workshop Survey Instructions

Your input is requested by January 7, 2021 on the following set of preliminary MRGESCP planning objectives (Appendix D from the 2020 Science & Adaptive Management Plan). Please provide a response for every item on the survey. Please refer to the information and definitions provided above and rate an objective and its associated strategies on the following scale:

1 – Strongly disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly agree

Use the scale provided to evaluate objectives on the following attributes:

- **A. Aligns with MRGESCP Mission Statement.**
- **B. Supports one or more MRGESCP Goals.**
- **C. Satisfies the definition of a S.M.A.R.T. statement.**
- **D. Addresses an issue considered to be a priority in the short-term (next 5 years).**

Use the scale provided to evaluate strategies on the following attribute:

- **E. Describes methods and/or resources needed to accomplish the associated objective.**

A worksheet is provided below to record your answers, but please feel free to provide additional feedback on the list using *Track Changes* to add comments, provide editorial markup or add your own suggested objectives and/or strategies. Return your completed survey to cmurphy@west-inc.com by 5 p.m. on Thursday, January 7, 2020.

Rio Grande Silvery Minnow

Objective A-1 A.____ B.____ C.____ D.____

Strategy A-1a E.____

Strategy A-1b E.____

Objective A-2 A.____ B.____ C.____ D.____

Strategy A-2a E.____

Strategy A-2b E.____

Objective A-3 A.____ B.____ C.____ D.____

Strategy A-3a E.____

Strategy A-3b E.____

Strategy A-3c E.____

Objective A-4 A.____ B.____ C.____ D.____

Strategy A-4a E.____

Strategy A-4b E.____

Strategy A-4c E.____

Objective A-5 A.____ B.____ C.____ D.____

Strategy A-5a E.____

Strategy A-5b E.____

Strategy A-5c E.____

Strategy A-5d E.____

Southwestern Willow Flycatcher

Objective B-1 A.____ B.____ C.____ D.____

Strategy B-1a E.____

Strategy B-1b E.____

Objective B-2 A.____ B.____ C.____ D.____

Strategy B-2a E.____

Objective B-3 A.____ B.____ C.____ D.____

Strategy B-3a E.____

Strategy B-3b E.____

Yellow-Billed Cuckoo

Objective C-1 A.____ B.____ C.____ D.____

Strategy C-1a E.____

Strategy C-1b E.____

New Mexico Meadow Jumping Mouse

Objective D-1 A.____ B.____ C.____ D.____

Strategy D-1a E.____

Strategy D-1b E.____

Pecos Sunflower

Objective E-1 A.____ B.____ C.____ D.____

Strategy E-1a E.____

Strategy E-1b E.____

Other Objectives and Strategies

Objective F-1 A.____ B.____ C.____ D.____

Strategy F-1a E.____

Strategy F-1b E.____

Objective G-1 A.____ B.____ C.____ D.____

Strategy G-1a E.____

Strategy G-1b E.____

PRELIMINARY COLLABORATIVE PROGRAM OBJECTIVES

Rio Grande Silvery Minnow

Objective A-1: Analyze available monitoring data for the RGSM from Cochiti Reservoir to Elephant Butte Reservoir to track population trends in the MRG.

Reclamation sponsors a population monitoring program to sample a minimum of 20 sites per year to document the presence or absence of marked and unmarked RGSM. This supports 1-A-1, 1-A-2, 2-A-1, and 2-A-2 recovery goals and criteria from the 2010 USFWS species recovery plan. This long-term monitoring effort provides indispensable data for evaluating the status of RGSM in the MRG.

> ***Strategy A-1a***: Continue to support this long-term monitoring effort, keeping it as a high-priority for the Collaborative Program. Explore additional applications of these data, if possible.
>
> ***Strategy A-1b***: Evaluate (temporarily) increasing the sample size and adding targeted sites to facilitate a statistically robust experimental design that addresses habitat use and informs habitat restoration efforts.

Objective A-2: Continue to support research into the life history of the RGSM to further inform management of the species.

Contributing to ongoing research of the life history of the species will help inform management decisions that benefit or reduce impacts to the species. The MRGESCP has developed a CEM useful for deriving questions about the RGSM's life history. This supports recovery goals 1, 2, and 3.

> ***Strategy A-2a***: Generate research proposals to address previous panel recommendations (Noon et al. 2016, Fraser et al. 2013, etc.) and CEMs uncertainties to better understand the life history of the RGSM.
>
> ***Strategy A-2b***: Track life history research using the AM Database to generate more timely management and study recommendations.

Objective A-3: Support research and modeling efforts to determine how much base flow is needed to produce sufficient habitat to support species survival rates necessary to achieve a self-sustaining population in each reach.

Base flows are important in maintaining wetted habitat, which represents the overall carrying capacity for the RGSM in any given area of the MRG. The following strategies support 2-B-1 and 3-B-1 recovery criteria from the 2010 USFWS recovery plan.

> ***Strategy A-3a***: Review current research publications and develop hypotheses to address habitat availability during base flow periods (outside of spring runoff).
>
> ***Strategy A-3b***: Support development of models, such as a Population Viability Analysis, to analyze habitat availability during base flow periods.
>
> ***Strategy A-3c***: Clearly define assumptions/uncertainties involving minimum base flow, sufficient habitat and survival rates.

Objective A-4: Support research and modeling efforts to determine timing, duration, and magnitude of flows needed to produce sufficient habitat in support of species recruitment rates for a self-sustaining population in each reach.

The timing, duration and magnitude of spring runoff are important to RGSM reproduction and have been demonstrated to have a significantly positive correlation with the October population density. The following strategies support recovery criteria 2-B-2, 2-B-3, 3-B-2, and 3-B-3 from the 2010 USFWS recovery plan.

> ***Strategy A-4a***: Review current research publications and develop hypotheses to address nursery habitat availability during spring runoff.

Strategy A-4b: Support development of models to analyze habitat availability during spring runoff.

Strategy A-4c: Clearly define assumptions/uncertainties involving flow characteristics, sufficient habitat and recruitment rates.

Objective A-5: Contribute to research and modeling efforts to better understand the quantity and quality of habitat needed at different flow regimes to support recruitment and survival of RGSM.

Habitat availability varies by reach and flow regime in the MRG and more research and modeling efforts are needed to help determine the best balance between water management and habitat restoration to support species recruitment and survival. The following strategies support recovery criteria 2-B-3, 2-B-4, 3-B-3, and 3-B-4 of the 2010 USFWS species recovery plan.

Strategy A-5a: Perform modeling to determine the amount of habitat needed in each reach during 1) spring runoff, 2) summer low flow periods, and 3) fall and winter base flow periods needed to support a self-sustaining population.

Strategy A-5b: Identify uncertainties related to recruitment of RGSM and perform literature reviews to develop research hypotheses on this topic.

Strategy A-5c: Identify uncertainties related to survival of RGSM and perform literature reviews to develop research hypotheses on this topic.

Strategy A-5d: Review new and existing research to identify specific metrics to measure habitat quality in supports of recruitment and survival of RGSM for a self-sustaining population in each reach. Recommend a habitat monitoring protocol to provide empirical data.

Southwestern Willow Flycatcher

Objective B-1: Continue monitoring for SWFL in designated critical habitat areas to track territories in the MRG management unit of the Rio Grande recovery unit.

SWFL territories and nests have been consistently found in the MRG management unit and the number of territories have increased in the last ten years. Continued contributions to monitoring in the MRG will help track species recovery. The following strategies support all recovery criteria listed in the 2002 USFWS species recovery plan.

Strategy B-1a: Ensure designated critical habitat areas in the MRG are monitored annually for SWFL territories to contribute to understanding species recovery.

Strategy B-1b: Analyze available monitoring data annually to ensure SWFL territories are not decreasing in the MRG management unit. If the number of territories are decreasing, review habitat areas where territories have decreased to make recommendations for improving habitat to increase SWFL territories.

Objective B-2: Continue monitoring critical SWFL habitat and contribute to research on the impacts from non-native and exotic species on SWFL recovery.

Habitat requirements for the SWFL have been well documented, but impacts from the management of the non-native and exotic tamarisk on SWFL recovery are poorly understood. The following strategy supports recovery criteria 2-B from the 2002 USFWS species recovery plan.

Strategy B-2a: Perform literature reviews and recommend best management practices regarding non-native and exotic species to support SWFL and their habitat.

Objective B-3: Support large-scale restoration efforts to protect and expand SWFL habitat in the MRG.

Strategy B-3a: Annually map or update maps of SWFL habitat in the MRG management unit.

Strategy B-3b: Review habitat areas biennially and identify sites that can be expanded based on occupied territories to prioritize restoration efforts.

Yellow-Billed Cuckoo

Objective C-1: Contribute to research and understanding of habitat needs for the YBCU.

Critical habitat areas were proposed and revised by the USFWS in 2020. The area includes much of the MRG with the exception of the Albuquerque reach. More research is needed to determine habitat features needed to help prevent up-listing of the YBCU. There is not currently a recovery plan for this species.

Strategy C-1a: Perform literature reviews and make recommendations for research to better understand the habitat needs to support the YBCU.

Strategy C-1b: Annually map or update maps of YBCU habitat in the MRG. Make recommendations to support expansion of habitat to support the species.

New Mexico Meadow Jumping Mouse

Objective D-1: Contribute to efforts to expand habitat and preserve existing habitat in the MRG.

There is currently one known population of NMMJM in the MRGESCP area, located at the Bosque del Apache National Wildlife Refuge. The biggest stressor to the species is habitat loss, typically a result of grazing, water management practices, drought, wildfire and other pressures. The following strategies support the findings in the 2014 USFWS recovery outline for the species.

Strategy D-1a: Provide a biennial assessment of opportunities to expand NMMJM habitat in the MRG to achieve a self-sustaining population.

Strategy D-1b: Perform literature reviews and pursue opportunities to support research to better understand the life history of the NMMJM, including movement behavior, to support habitat recommendations.

Pecos Sunflower

Objective E-1: Continue monitoring for PESU stands in the West-Central New Mexico Recovery Region and preserve habitat.

In the 2005 species recovery plan, the USFWS listed at least one potential core conservation area for an existing population of PESU within the West-Central New Mexico Recovery Region in the MRGESCP area – the La Joya State Waterfowl Management Area. The area around the La Joya Drain is of particular interest. Monitoring and maintenance in that area should consider how to improve habitat for PESU.

Strategy E-1a: Monitor one new area per year for PESU to see if species is present. Monitoring could occur simultaneously with other monitoring occurring for habitat restoration sites or site maintenance monitoring. Consider monitoring in newly restored habitat areas in the Lower Reach Plan, where habitat for PESU may be become suitable.

Strategy E-1b: Devise a list of potential ways to keep the La Joya Drain area perennial to continue to provide suitable habitat for the PESU.

Other Objectives and Strategies

Objective F-1: Monitor the status of other threatened species in the MRG.

The Collaborative Program will track the status of other species of concern in the MRG to prevent future listings or up-listings within the MRGESCP area.

Strategy F-1a: Review the biennial assessment from the NMDGF for status of various species in the MRGESCP area. Consider including protection measures for applicable threatened species in restoration efforts, where possible.

Strategy F-1b: Include an update on status of other threatened and endangered species at the Science Symposium.

Objective G-1: Support the establishment and maintenance of a Conservation Storage pool in Abiquiu Reservoir.

Efforts are underway to change authorizations at Abiquiu Reservoir so native Rio Grande water can be stored in addition to the already authorized San Juan-Chama water storage. The flexibility to store both San Juan-Chama and native Rio Grande water will provide options for managing water resources on the MRG.

Strategy G-1a: Provide monitoring data to support the environmental assessment process to establish the conservation storage pool.

Strategy G-1b: When possible, find available water to support the conservation storage pool to benefit species and habitat.

Middle Rio Grande Endangered Species Collaborative Program (MRGESCP)
Science & Technical (S&T) Ad Hoc Group
Charge Template

Approved by Science and Adaptive Management Committee (SAMC) on *DATE*.

Parent Committee
S&T Ad Hoc Groups are formed by and report to the SAMC.

Ad Hoc Group Charge
Detail the charge of the S&T Ad Hoc Group below, including specific tasks directed by the SAMC. Include the objectives addressed by those tasks.

Membership

A. Criteria for membership
Provide a list of qualifications and/or interests that members should possess in order to sit on the ad hoc group

B. Member List
List the proposed members of the S&T Ad Hoc Group here, including affiliation and job title. The total membership should take into account the expertise needed to carry out the group's charge, and the group should be kept at a manageable size in order to complete the task within the timeline detailed in this document.

Tasks and Deliverables
List the specific tasks the group is being directed to complete to fulfill their charge. Provide the deliverable(s) associated with each task. Tasks can be a concrete activity (e.g., data analysis, a scope of work, a model), but can also be process-oriented (e.g., develop options for addressing a hypothesis for the SAMC's consideration).

1. ***Task One Name***
Details of task one

Objective of Task One
How will this task contribute to the group's overall charge?

Deliverable(s):

2. ***Task Two Name***
Details of task two

Objective of Task Two
How will this task contribute to the group's overall charge?

Deliverable(s):

Add or delete numbers for additional tasks as needed.

Timeline and Reporting Scheduling

Complete the table below to note when tasks should be completed and deliverables submitted to the SAMC for review. The tasks in the table should match with those listed above. Each task should include reports to the SAMC.

Task	Subtask	Deliverable	To Be Completed By
Task one	Subtask 1A	Deliverable Name	Deadline
	Subtask 1B	Deliverable Name	Deadline
Task two		Deliverable Name	Deadline

Appendix B. Rio Grande Silvery Minnow Conceptual Ecological Model

RIO GRANDE SILVERY MINNOW LIFE HISTORY

The RGSM is a small-bodied member of the Cyprinid family, native to the Rio Grande basin. The RGSM once occurred throughout the Rio Grande Basin from the MRG (Rio Grande Reaches found in New Mexico) all the way to the Gulf of Mexico. Historically, it was also found in important tributaries such as the Rio Chama, Jemez River, and Pecos River (Sublette et al. 1990, Bestgen and Platania 1991, Horwitz et al. 2018). Currently, the RGSM only occupies approximately seven percent of its historic range (USFWS 2010, Mortensen et al. 2019). The majority of the current population is found in the 280km reach of the MRG between Cochiti Dam and Elephant Butte Reservoir, with a much smaller, experimental population introduced into a small portion of the Rio Grande near Big Bend, TX in 2008. Limited natural reproduction occurs within the MRG population, however the Big Bend population is not thought to be self-sustaining at this time (USFWS 2008, Edwards 2017). The contraction of the RGSM's range is mostly attributed to modifications in hydrology as a response to anthropogenic changes in water use and storage in the basin (USFWS 2016, 2018). The loss of RGSM habitat and the overall decline in abundance ultimately resulted in the species being listed as endangered under the ESA in 1994.

The life history for the RGSM is typical of similar small-bodied, riverine cyprinids that occupy lowland floodplain rivers of Western North America (Platania et al. 2020). Spawning begins in the spring during the freshet, just prior and during peak flows (typically mid-April to mid-May). The exact mechanism that initiates spawning is still unknown, but it is likely related to hydrologic and temperature cues (Dudley et al. 2018, USFWS 2018). RGSM are broadcast spawners and highly fecund; a single female may produce anywhere from 2,000 to 10,000 eggs (Caldwell et al. 2019). Eggs become semi-buoyant after fertilization and drift downstream while they incubate. Eggs incubation typically lasts for 24 to 48 hours and is highly temperature dependent (Platania 2000). The spawning strategy of the RGSM depends on reliable flows that are able to disperse eggs and larvae into slower moving, overbank and floodplain nursery habitats (Gonzales et al. 2014). Larvae hatch from their eggs at only 4mm standard length (SL) and on average, become free swimming four days later once they reach 5-10mm SL. Larvae are gape limited and known to eat algae, diatoms, small invertebrates, cyanobacteria, detritus, periphyton, seeds and pine pollen (Shirey et al. 2008, Magana 2009, Watson et al. 2009, Bixby and Burdett 2014). The larval life stage lasts until mid-July when they transition to juveniles (13-64 mm SL).

Juveniles primarily occupy in-channel habitats as floodplain habitats begin to recede with declining freshet flows. These habitats are notably deeper and in faster waters compared to larval habitat. Juvenile RGSM have a similar diet to that of larvae, as RGSM tend to be generalists. During the summer, it is common for portions of the MRG to dewater, leading to fragmentation of suitable RGSM habitats. When dewatering occurs, RGSM experience high levels of mortality due to a lack of suitable available habitat and stranding. Juveniles continue to grow through the summer and fall before transitioning into adults (35-90 mm SL) beginning in December.

Adults have almost identical habitat use and diet as juveniles. During the winter RGSM occupy deeper, slower habitat with adequate cover where they can conserve energy (Platania and Dudley 2003). Sexual maturity is often achieved in less than 12 months, thus fish hatched in the previous spring are able to contribute to the population during the following spawning season. The typical life span of RGSM in the MRG is two years, however individuals as old as five years have been observed (Dudley et al. 2018, Horwitz et al. 2018).

CONCEPTUAL ECOLOGICAL MODEL DESCRIPTION

The RGSM CEM describes and depicts the life history of RGSM and all the biotic and abiotic factors of the MRG that influence the RGSM population. With that in mind, a graphical representation of the RGSM life cycle was developed as the basis for the model (Figures 6 and 7). The CEM is a variation of an influence diagram, which documents relationships between model components using arrows. There are four types of model components in this CEM, each is presented by a different shaped node as shown in Box B1.

Box B1. Rio Grande Silvery Minnow Conceptual Ecological Model Components (Nodes)

1. Life Stage	The different RGSM life stages are depicted as ovals. The life stages progress from left to right in the CEM.
2. Probability	Probabilities use square rectangles. In the CEM a probability can be a survival rate or an environmental probability (e.g., probability of the channel drying)
3. Environment	Habitat and environmental components are depicted as rounded rectangles. These model nodes refer to non-probabilistic components of the environment that RGSM may encounter. These can represent both biotic (e.g., predation) and abiotic (e.g., Adult habitat) features that influence RGSM population dynamics.
4. Management	Management actions are displayed using a hexagram and indicate which nodes of the model would be influenced if a particular management actions were enacted.

Each CEM node is connected to at least one other node using arrows. The direction of the arrow indicates the direction of the influence in the relationship and flow of information. All arrows are unidirectional, meaning a single arrow can only represent a single relationship. The thickness of the arrow represents the importance that the parent node (origin) has on the child node (destination; Figure B2). The color of the arrow indicates the current level of understanding of that relationship as shown in Table B1. Black arrows in the model indicate life stage transitions.

Table B1. Arrows of Influence and Understanding Depicted in the Rio Grande Silvery Minnow Conceptual Ecological Model

Level of Understanding	Importance of Parent Node to Child Node	Understanding of Relationship
High	→	→
Medium	→	→
Low	→	→

COMPONENT GROUPS

Ten categories that all the current model components fall under were defined to determine general patterns in the understanding of the factors that influence the RGSM. These categories also allow a focus on specific areas of future study. They are defined in Table B2.

In general, the CEM follows the life history of RGSM from adults in time step t, to adults in time step t+1. The CEM moves from left to right as adults in time step t spawn to create eggs, which then progress as larvae, juveniles, and finally adults in the next time step (t+1). Mortality is applied between each time step in the form of survival probabilities. Survival probabilities are informed by various child nodes in the lower portion of the model. A full description of each individual model component can be found in Table B3.

Table B2. Rio Grande Silvery Minnow Conceptual Ecological Model Component Groups

1. Life History	Life history nodes are either RGSM life stages or population vital rates. These components are the end points for most of the other components in the model and comprise the RGSM life cycle.
2. Food Availability	Food availability nodes represent food availability for the RGSM at its three different feeding life stages: larval, juvenile, and adult. Food availability directly influences age-specific survival rates.
3. Predation	Predation nodes represent the three most common predator categories: fish, avian, and invertebrate. RGSM are prey to a variety of other species in the MRG, and predation rates directly influence RGSM age-specific survival.
4. Hydrology	Hydrology is a large node because of its large influence and interconnectedness on the system. It influences the RGSM life cycle in the form of temperature, flow, and floodplain inundation. Most hydrologic components are related to flow (Q).
5. Geomorphology	Geomorphic nodes reflect the processes that shape the physical shape and environment of the river. These processes determine sediment scouring/deposition, overall river geometry, and other river hydraulics.
6. Habitat	Three types of habitat occupied by RGSM are defined as: larval, juvenile, and adult. In general, RGSM use a wider range of stream velocities and depths as they grow from larvae to adults. Habitat availability may directly influence age-specific survival rates.
7. Vegetation	Vegetation nodes refer to the diversity and density of vegetation that exists in the floodplains and main channel of the MRG. Vegetation helps determine floodplain inundation and overall river geometry.
8. Disease and Parasites	Hydrology is a large model component grouping because of its large influence and interconnectedness on the system. It influences the RGSM life cycle in the form of

	temperature, flow, and floodplain inundation. Most hydrologic components are related to flow (Q).
9. Genetics	The level of genetic diversity is the only model component in this grouping. Genetic diversity is informed by the density of adults present in the system and influences overall fecundity.
10. Photoperiod	The photoperiod model component may be a spawning cue and may only influences fecundity. Photoperiod is the change in the amount of daylight through the year.

CONCEPTUAL ECOLOGICAL MODEL SCALE

This CEM assumes specific spatial and temporal scales. Spatially, the extent of this model includes four reaches of the MRG, with a grain size equal to four separate reaches. This scale also means the model is spatially implicit at resolutions finer than reaches listed above. For example, fish occupying different parts of the same reach are assumed to experience the same mortality rates and have same access to habitat. The Northern Reach was described in Section 1.3 and shown in Figure 1 of the Science & AM Plan was excluded from the spatial scale of this CEM as RGSM do not exist in the Northern Reach. For the purposes of understanding the RGSM CEM spatial scale, the four reaches have been defined in Section 1.3 of the Science & AM Plan.

The current format of the CEM only depicts the direction, importance, and the current level of understanding of each relationship between model components. At this time, it is not possible to identify specific mechanisms for each relationship defined in the CEM. However, this model is intended as a tool to help managers and stakeholders identify the components and relationships that are most influential to the management of RGSM.

Temporally, the model operates with an annual time step. Although much of the biology of the RGSM occurs as finer spatial and temporal scales, little monitoring is done in order to build a useful system-wide model that can operate at those fine resolutions (e.g., 10km reaches or at a daily time step). The scale was chosen to reflect the current monitoring methods and population dynamic modeling efforts. The collection of transition schematics (Figures B1) were used to derive the graphical model (Figure B2).

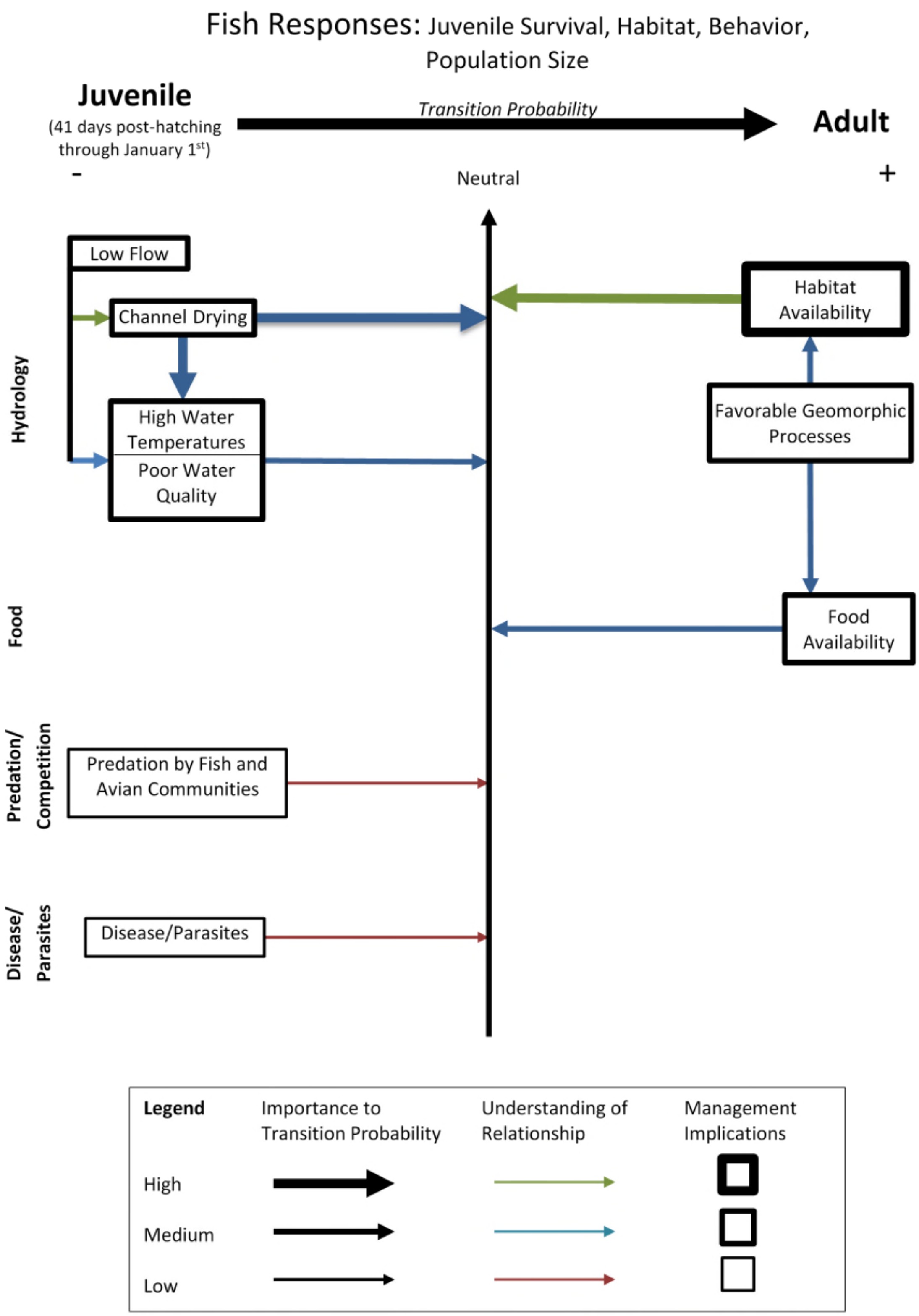

Figure B1. Rio Grande Silvery Minnow Life History Transition Schematics.

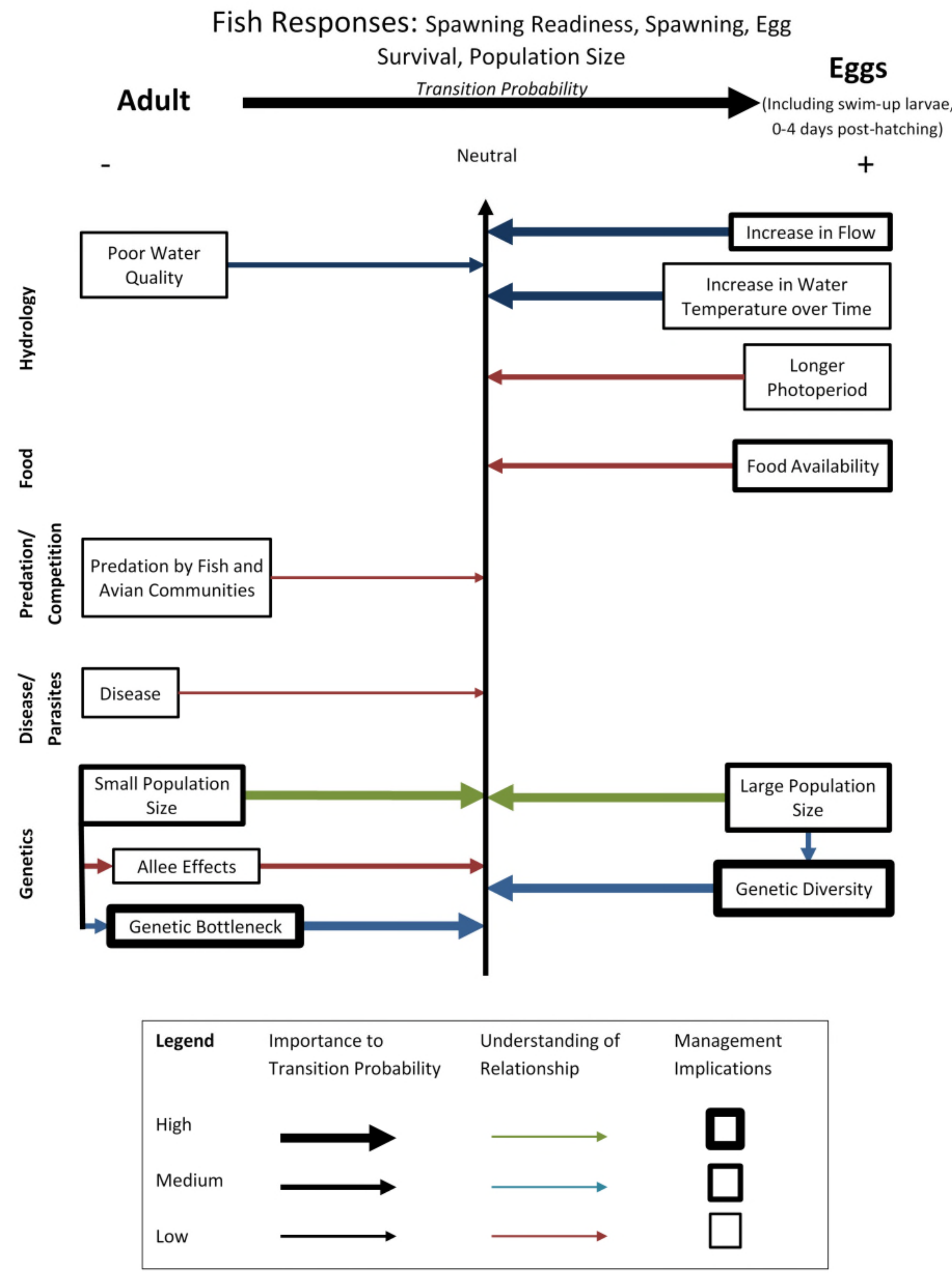

Figure B1 (continued). Rio Grande Silvery Minnow Life History Transition Schematics.

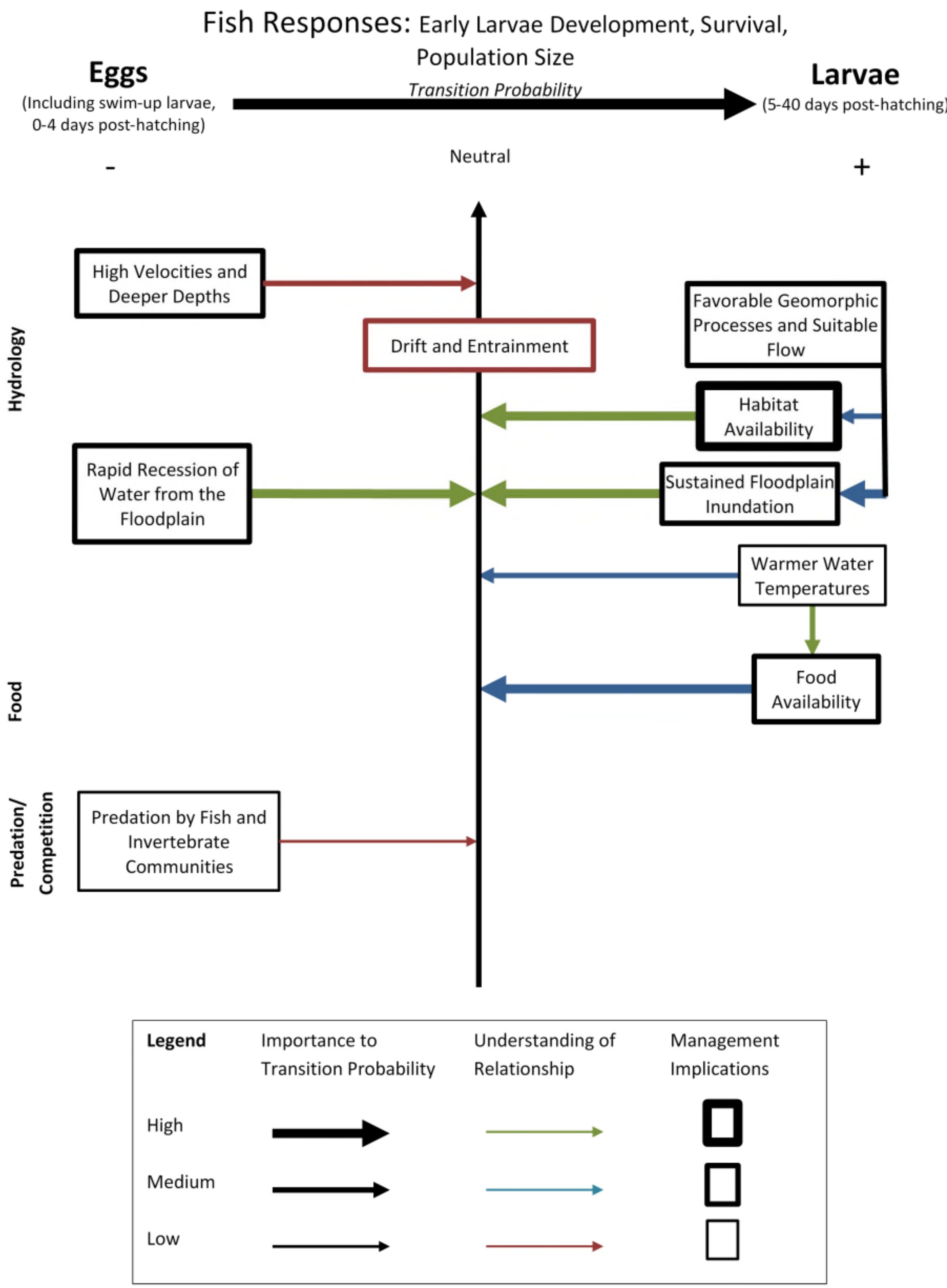

Figure B1 (continued). Rio Grande Silvery Minnow Life History Transition Schematics.

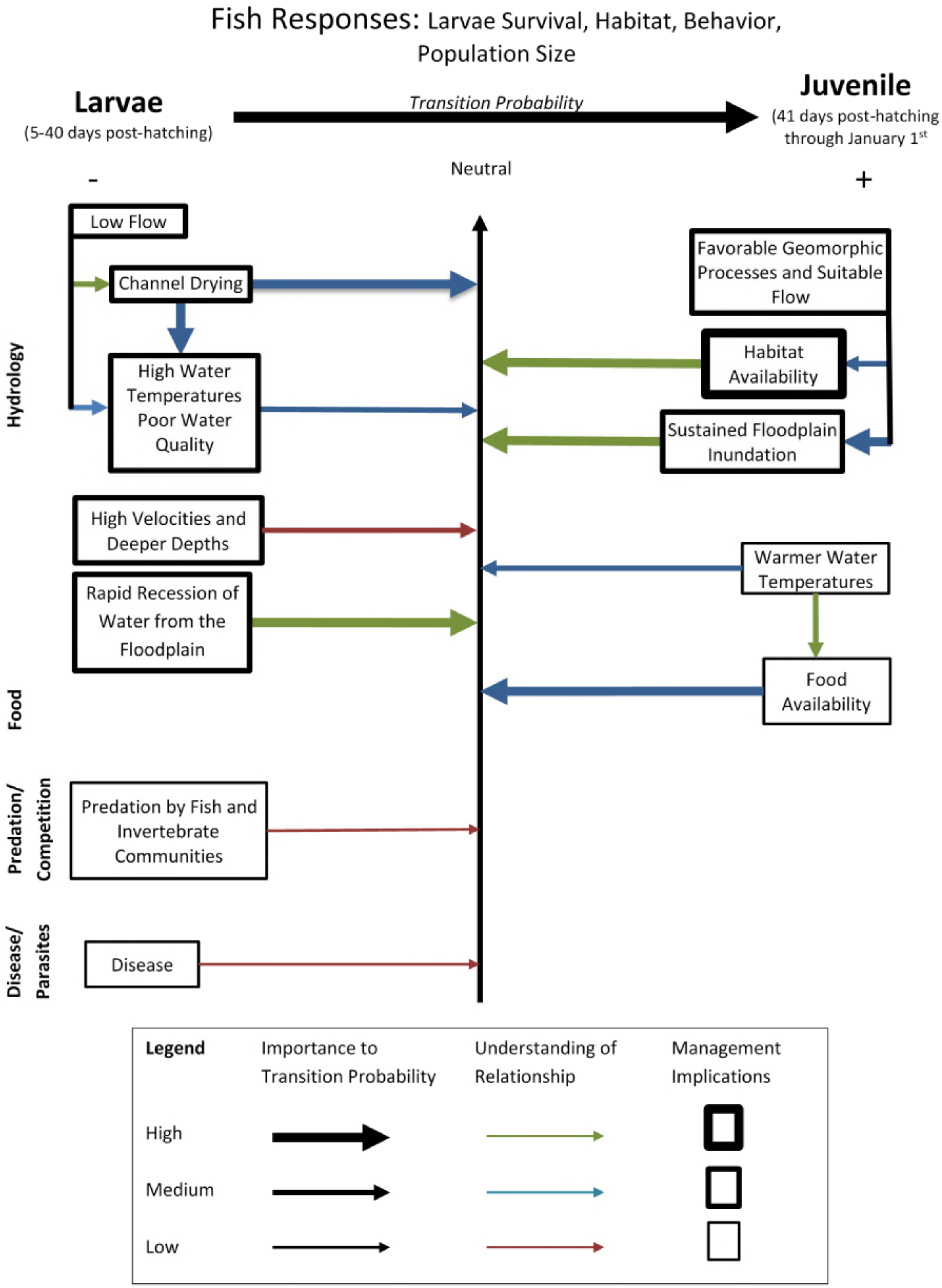

Figure B1 (continued). Rio Grande Silvery Minnow Life History Transition Schematics.

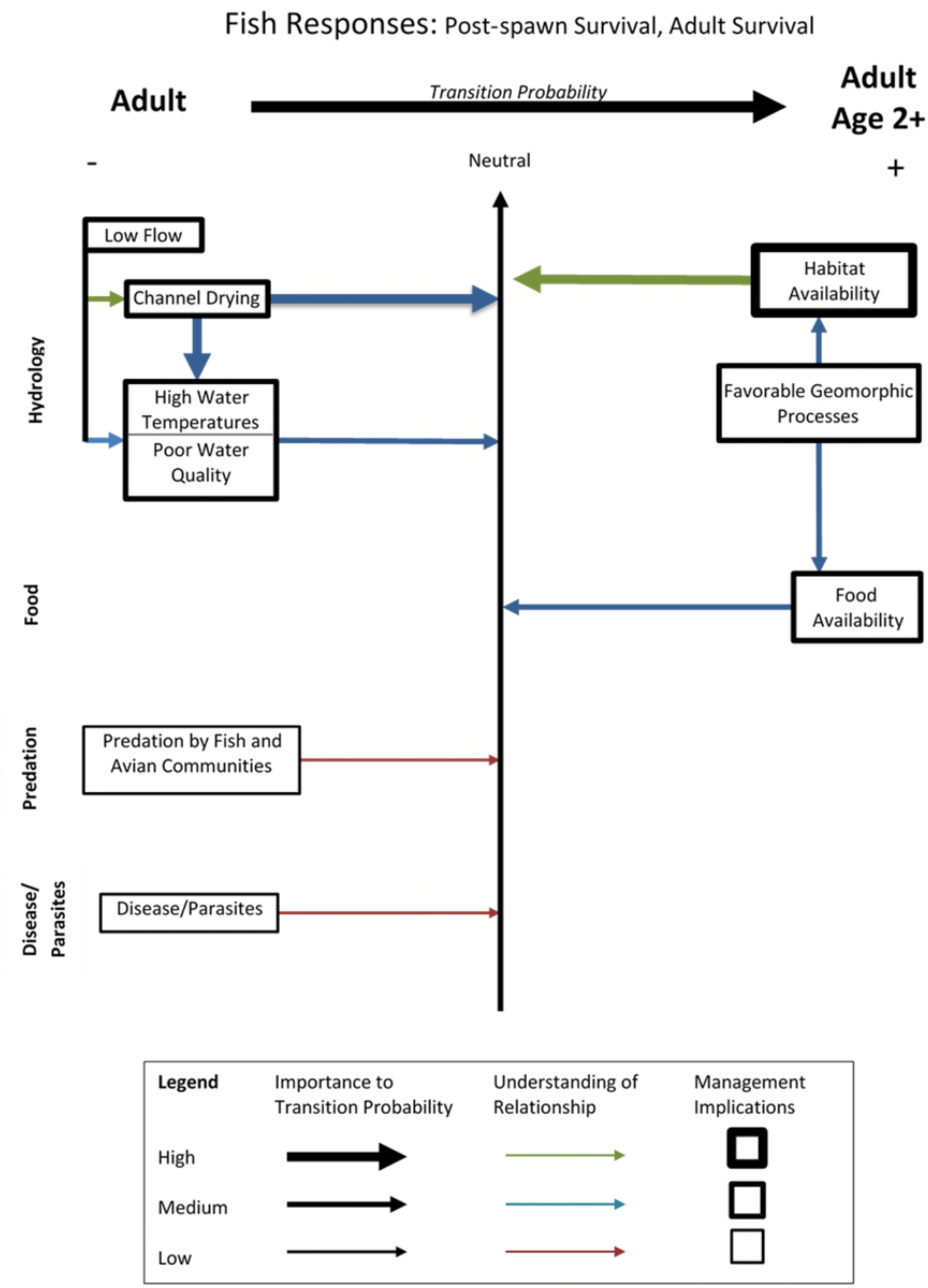

Figure B1 (continued). Rio Grande Silvery Minnow Life History Transition Schematics.

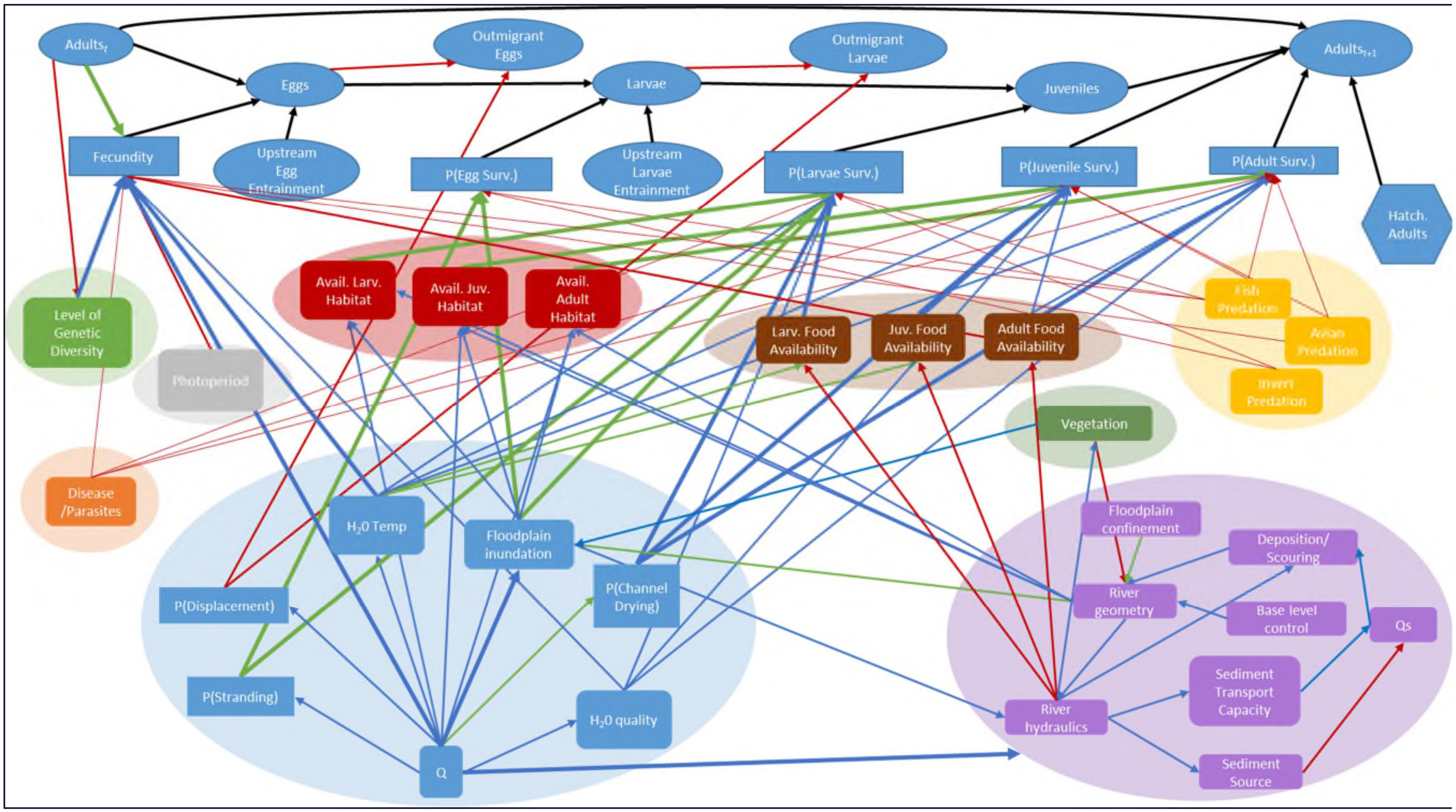

Figure B2. Graphical conceptual ecological model for the Rio Grande silvery minnow. Each model node is connected to at least one other node using arrows. The direction of the arrow indicates the direction of the influence in the relationship and flow of information. The thickness of the arrow represents the importance that the parent node (origin) has on the child node. The color of the arrow indicates the current level of understanding of that relationship (Red=low, Blue=Medium, Green=High). Black arrows indicate life stage transitions.

Child Node (Destination of arrow/influence)

Parent Node (Origin of arrow/influence)	RGSM Life History																	Food Avail.			Predation				Hydrology							Habitat			Geomorphology								
	Adults$_t$	Eggs	Larvae	Juveniles	Adults$_{t+1}$	Upstream Egg Entrainment	Outmigrant Eggs	Upstream Larvae Entrainment	Outmigrant Larvae	Fecundity	P(Egg Surv.)	P(Larvae Surv.)	P(Juvenile Surv.)	P(Adult Surv.)	Hatch. Adults	Level of Genetic Diversity	Disease/Parasites	Larv. Food Availability	Juv. Food Availability	Adult Food Availability	Fish Predation	Avian Predation	Invert. Predation	Vegetation	Q	H_2O Temp	H_2O Quality	Floodplain Inundation	P(Displacement)	P(Stranding)	P(Chanel Drying)	Avail. Larv. Habitat	Avail. Juv. Habitat	Avail. Adult Habitat	Qs	Sediment Source	Sediment Transport Capacity	Base Level Control	Deposition/Scouring	Floodplain Confinement	River Geometry	River Hydraulics	Photoperiod
Adults$_t$	x	grey			grey											M (red)																											
Eggs		x	grey				grey																																				
Larvae			x	grey					grey																																		
Juveniles				x	grey																																						
Adults$_{t+1}$					x																																						
Upstream Egg Entrainment		grey				x																																					
Outmigrant Eggs							x																																				
Upstream Larvae Entrainment			grey					x																																			
Outmigrant Larvae									x																																		
Fecundity		grey								x																																	
P(Egg Surv.)			grey								x																																
P(Larvae Surv.)				grey								x																															
P(Juvenile Surv.)					grey								x																														
P(Adult Surv.)					grey									x																													
Hatch. Adults					grey										x																												
Level of Genetic Diversity										H (blue)						x																											
Disease/Parasites										L (red)		L (red)	L (red)	L (red)			x																										
Larv. Food Availability												H (blue)						x																									
Juv. Food Availability													H (blue)						x																								
Adult Food Availability														H (blue)						x																							
Fish Predation										L (red)	L (red)	L (red)	L (red)	L (red)							x																						
Avian Predation										L (red)			L (red)	L (red)								x																					
Invert. Predation											L (red)	L (red)											x																				
Vegetation																								x																	M (red)		
Q										H (blue)															x	H (blue)	L (blue)	H (blue)	L (blue)	L (blue)	M (green)	M (blue)	M (blue)	M (blue)	H (blue)	H (blue)	H (blue)	H (blue)	H (blue)	H (blue)	H (blue)	H (blue)	
H_2O Temp										H (blue)		M (blue)	M (blue)	M (blue)				M (green)	M (green)							x																	
H_2O Quality										M (blue)		M (blue)	M (blue)	M (blue)													x																
Floodplain Inundation											H (green)	H (green)																x				M (blue)	M (blue)	M (blue)							M (green)	M (blue)	
P(Displacement)							M (red)		M (red)																				x														
P(Stranding)											H (green)	H (green)																		x													
P(Chanel Drying)												H (blue)	H (blue)	H (blue)																	x												
Avail. Larv. Habitat												H (green)																				x											
Avail. Juv. Habitat													H (green)																				x										
Avail. Adult Habitat														H (green)																				x									
Qs																																			x				M (blue)				
Sediment Source																																			M (red)	x							
Sediment Transport Capacity																																			M (blue)		x						
Base Level Control																																						x			M (blue)		
Deposition/Scouring																																							x		M (blue)		
Floodplain Confinement																																								x	M (green)		
River Geometry																																M (blue)	M (blue)	M (blue)							x		
River Hydraulics																		M (red)	M (red)	M (red)				M (blue)												M (blue)	M (blue)		M (blue)			x	
Photoperiod										M (red)																																	x

Figure B3. Conceptual ecological model (CEM) relationship matrix. The matrix describes every relationship (arrow) in the CEM. Rows indicate the component where the relationship originates and columns show the component where the relationship ends (e.g., direction of the CEM arrow). The color of the cell indicates level of understanding of that relationship (Red=low, Blue=medium, Green=high) and the letter in each cell indicates the importance that the parent node (origin) has on the child node (L=low, M=medium, H=high). Grey boxes indicate life history transitions and blank cells represent no relationship.

Table B3. Conceptual Ecological Model Component Descriptions

Component	Category	Description
$Adults_t$	Life History	Adult abundance at time step *t*. Adults are present year round in the MRG and are classified as individuals >35mm. The age structure of the adults is predominately made up of 1 and 2 year old fish, however a small segment of fish can live up to 5 years. All adults are considered sexually mature and available to spawn.
Eggs	Life History	Total number of eggs produced during spawning during time step *t*. calculated by applying the spawning success rate (*P(Spawning Success)*) to $Adults_t$.
Larvae	Life History	The number of larvae produced during time step *t*. calculated by applying the egg survival rate (*P(Egg Surv)*) to *Eggs*. Larvae are classified as individuals between 4 and 13mm standard length and can be found in the MRG between mid-April to mid-July.
Juveniles	Life History	The number of Juveniles produced during time step *t*. calculated by applying larval survival rate (*P(Larvae Surv.)*) to *Larvae*. They are classified as individuals between 13 and 64mm standard length and can be found in the MRG between mid-July to December.
$Adults_{t+1}$	Life History	Adult abundance at time step *t+1.* This group is comprised of both Juveniles that survive into adulthood as well as Adults from the previous time step *t*.
Upstream Egg Entrainment	Life History	The total number of eggs that are entrained from upstream reaches.
Out-migrant Eggs	Life History	The total number of eggs that disperse downstream out of the system/reach.
Upstream Larvae Entrainment	Life History	The total number of larvae that are entrained from upstream reaches.
Out-migrant Larvae	Life History	The total number of larvae that disperse downstream out of the system/reach.
Fecundity	Life History	The mean number of eggs produced by an individual RGSM.
P(Egg Survival)	Life History	The mean probability that an individual egg will survive to hatching during time step *t.*
P(Larvae Survival)	Life History	The mean probability that an individual larvae will survive to transition into the juvenile life stage during time step *t*.
P(Juvenile Survival)	Life History	The mean probability that an individual juvenile will survive to transition into the adult life stage during time step *t*.
P(Adult Survival)	Life History	The mean probability that an individual adult will survive to the next time step *t*.
Hatch. Adults	Life History	The number of hatchery origin adults stocked into the reach.
Level of Genetic Diversity	Genetics	The total amount of RGSM genetic diversity present in the MRG.
Disease/Parasites	Disease/Parasites	The prevalence of disease and parasites that can adversely affect survival rates of RGSM.
Larval Food Availability	Food Availability	The density of suitable diet items available for consumption by larval RGSM.
Juv. Food Availability	Food Availability	The density of suitable diet items available for consumption by juvenile RGSM.
Adult Food Availability	Food Availability	The density of suitable diet items available for consumption by Adult RGSM.
Fish Predation	Predation	The prevalence of fish that prey on RGSM.

Avian Predation	Predation	The prevalence of birds that prey on RGSM.
Invert. Predation	Predation	The prevalence of invertebrates that prey on RGSM.
Vegetation	Vegetation	The diversity and density of vegetation that can influence the geomorphic processes in the MRG.
Q	Hydrology	Discharge referring to the magnitude (in terms of peak discharge or volume of water), duration (how long does flood last), frequency (how often it occurs, what time of year it occurs), and time sequence (the occurrence of discharge events within a year or over multiple years/decades)
H_20 Temp	Hydrology	In-stream temperature.
H_20 Quality	Hydrology	General water quality.
Floodplain Inundation	Hydrology	The amount of floodplain habitat created during spring run off or during other water management activities.
P(Displacement)	Hydrology	The probability that high flows may displace and disperse eggs and larvae out of the system.
P(Stranding)	Hydrology	The probability that high flows that create floodplain habitat may recede too quickly and strand RGSM eggs and larvae in disconnected floodplains
P(Channel Drying)	Hydrology	The probability low flows may cause portions of the main channel to dry and fragment RGSM habitats.
Available Larval Habitat	Habitat	The total amount of RGSM larval habitat available to larval RGSM.
Available Juvenile Habitat	Habitat	The total amount of RGSM Juvenile habitat available to Juvenile RGSM.
Available Adult Habitat	Habitat	The total amount of RGSM Adult habitat available to Adult RGSM.
Qs	Geomorphology	Sediment load referring to the magnitude (peak concentration or load or volume of sediment), gradation of sediment, portion of sediment size class moving in suspension or as bed load (or in between), etc.
Sediment Source	Geomorphology	Where the transported sediment comes from (banks or beds of river, uniform or concentrated deposition sources from tributary inputs – e.g., fines from a tributary may coat a large section of a river, whereas coarser material deposits on the alluvial fan at the tributary confluence). The sources may be recent deposits, older deposits that have consolidated, or erosion of the bed or bank).
Sediment Transport Capacity	Geomorphology	The theoretical ability of the channel to move sediment of a given size class.
Base Level Control	Geomorphology	The influence of reservoir or in-stream channel features to cause backwater effects influencing river geometry and river hydraulics
Deposition/ Scouring	Geomorphology	The process of sediment being added or subtracted to a given cross section. This is dependent on grain size and both processes may occur at a given location (e.g., bank could be eroding while at the same time deposition is occurring on a bar opposite the erosion).
Floodplain Confinement	Geomorphology	The lateral constraint of the river from local geology or placement of engineered/spoil levees.
River Geometry	Geomorphology	The slope, width, mean depth, channel sinuosity, channel planform, cross section shape, wetted perimeter, XS area
River Hydraulics	Geomorphology	How fast the water is moving (velocity), depth of the water, force water applies at interfaces (shear stress, drag, water buoyancy, etc.)
Photoperiod	Photoperiod	The changes in day light duration during the spring time which may act as a spawning cue.

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Appendix C. Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Conceptual Ecological Models

LIST OF FIGURES

AVIAN SPECIES CONCEPTUAL ECOLOGICAL MODELS

The CEMs for the SWFL and the YBCU were developed in tandem and are very similar. Both were developed around the species' life cycle, and as both are neo-tropical migratory songbirds, the basic life stages are the same (Figure C1). With the exception of the Migration Southbound, Overwinter, and Migration Northbound, all other life stages are applicable to the MRG.

The avian species CEMs do not show relationships between variables in the way that the RGSM CEM does. Much uncertainty exists in both the SWFL's and the YBCU's basic life history. These knowledge gaps must be addressed before building a relational CEM like that of the RGSM.

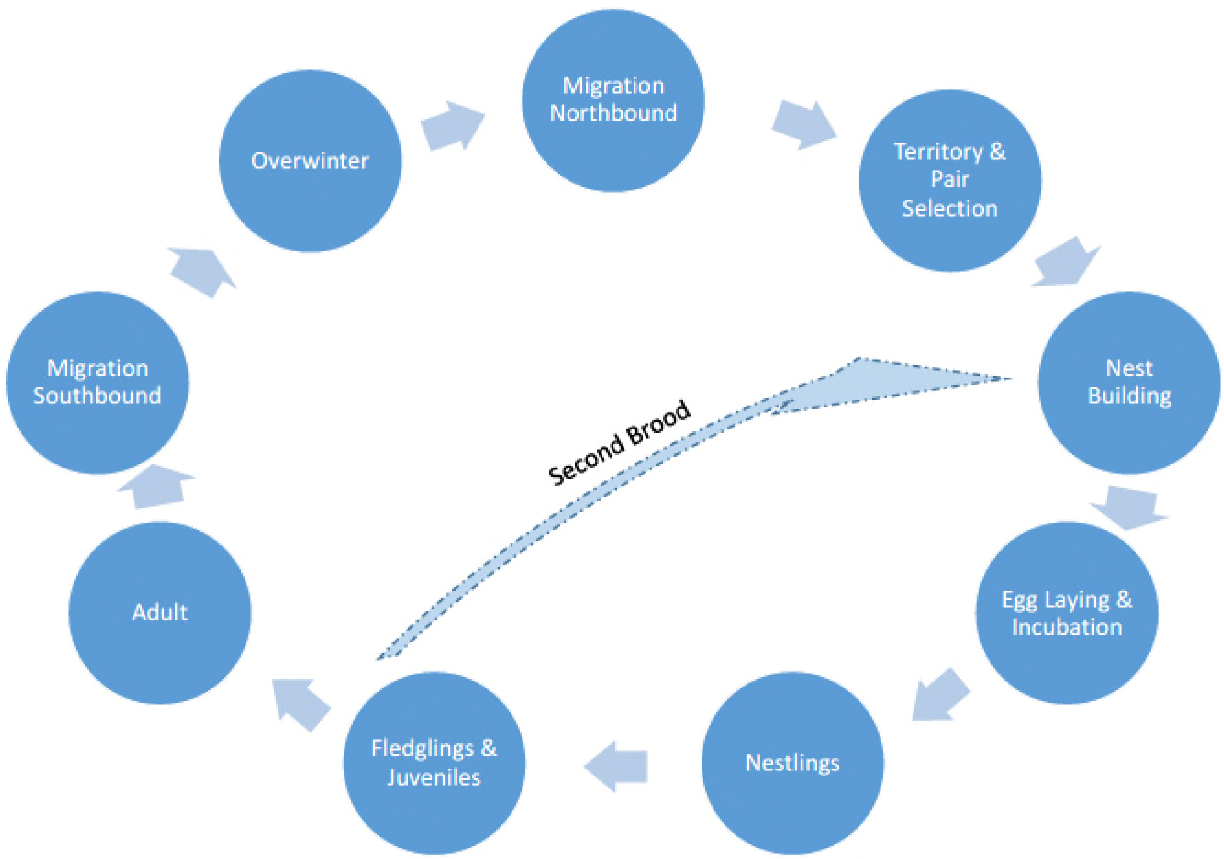

Figure C1. Basic Life Cycle for the Southwestern Willow Flycatcher and Yellow-Billed Cuckoo

Southwestern Willow Flycatcher Life History

The SWFL is a small perching bird of less than 15 centimeters long from bill to tail. It was listed as endangered in 1995 (Sogge et al. 2010). A primary reason for the species decline is the lost and degradation of its dense, native riparian habitat due to the anthropogenic modification of waterways through channelization and damming, water diversions and groundwater pumping, and alterations to the riparian zone. It is one of four recognized subspecies of willow flycatcher. SWFLs overwinter in Mexico, Central America, and northern South America. They migrate north to breed in dense riparian habitats in the Southwest, including in the MRG (USFWS 2002).

The USFWS-designated critical habitat was revised in January 2013 to follow Recovery Plan goals, and identifies 1,975 stream kilometers in Arizona, New Mexico, southern California, Nevada, Utah, and Colorado that the species uses as breeding habitat (USFWS 2013). Their current range is similar to their historic range, but population numbers have declined due to the loss of suitable riparian habitat.

Northbound migrating SWFL arrive in the MRG in early May, and they select territories and mating pairs through the spring (USFWS 2002; Sogge 2010). Little information exists on SWFL pair selection. The female of the breeding pair ultimately chooses the nest site, looking for territory that can provide food, water, and shelter. SWFL breeding pairs prefer dense riparian habitat near or adjacent to surface water or with saturated soil, which are important both for creating a microclimate at the nest site and as habitat for their prey base of flying insects, such as mosquitoes(Sedgwick 2000; USFWS 2002; Sogge 2010). Generally, the nesting site is characterized by multi-age vegetation stands with 50-75 percent mid-story cover and dense cover that is 3-6 meters high (USFWS 2002). This dense vegetation provides protection from predators and contributes to the cooler microclimate of the nest site (Sedgwick 2000). The species also exhibit site fidelity, and breeding pairs have been observed returning to the same nesting site in subsequent years, even if the quality has degraded.

Within two weeks of pair selection, the female builds a cup-shaped nest over the course of 5-7 days without help from the male (USFWS 2002; Sedgwick 2020). Egg laying generally occurs from mid-May through mid-June. SWFLs lay 3-4 eggs per clutch over a span of 4-5 days. Eggs hatch in 12-14 days. Once hatched, the nestlings remain in the nest for 14-15 days before they fledge (leave the nest but are not fully independent from the parents). SWFL fledglings are capable of short flights (approximately 30 meters), and after leaving the nest, will remain in their parents' nesting territory for about 14 days before dispersing (Sedgwick 2020).

There is very little information on SWFL young of year once they have fledged and become juveniles, as surveys stop at that life stage. The life history of SWFL between fledging and leaving for the southern migration is a large data gap. Broods likely break up once they become juveniles as there have been no reports of flocking of immature SWFLs.

SWFLs sometimes have a second brood within a single breeding season. The likelihood of a second brood increases if the offspring from the first clutch fledge by late June or very early July. Re-nesting is common if the first nest is lost or abandoned. Clutch size decreases with each nest attempt. The proximity of the second nest to the first varies greatly, and could even be in the same plant or up to several kilometers away (USFWS 2002; Sedgwick 2020).

Migration south to their overwinter grounds begins sometime in mid-August through September, though due to survey efforts being focused around the breeding season, there is uncertainty around the exact timing of the migration and the factors that influence that timing (USFWS 2002)

Yellow-Billed Cuckoo Life History

The Western U.S. Distinct Population Segment (DPS) of the YBCU was listed as threatened under the ESA October 3, 2014 (USFWS 2014).[4] YBCU are medium-sized birds of about 30 centimeters in length. Their historic range was west of the Continental Divide, stretching from British Columbia down to northern Mexico. Today, the Western DPS of the YBCU's breeding habitat is along rivers in Arizona, California, and New Mexico (USFWS 2014; Hughes 2020). YBCU are riparian species and require large expanses of riparian habitat at the landscape level with a mosaic of different vegetation (Johnson 2009; Hughes 2020).

The species arrive at their breeding grounds in mid-late May to mid-June (Sechrist et al 2012; Hughes 2020). Little is known about pair selection (Johnson 2009). YBCU require a nest patch size of about five hectares with 50-75 percent mid-story cover that is 3-10 meters high. YBCU foraging territory is even larger, with individuals observed to have territories of 75-100 hectares (Johnson 2009; Dillon and Moore 2020).

At the nest patch scale, canopy cover is critical to provide protection and the microhabitat necessary for nest success. YBCU also prefer nest habitat in close proximity to water, especially if there is a low velocity flow of shallow depth underneath the nest. This also contributes to the nest microclimate, and provides habitat for an insect prey base. Both the male and female build the nest over the course of several days, which is located on a horizontal branch or fork of a tree (Hughes 2020).

While females can lay between 1-5 eggs per clutch, clutch size is usually 2-3 eggs. One egg is usually laid every other day, but females may wait up to five days between eggs. Eggs are incubated over 9-11 days. The duration of the egg laying and incubation period varies, between 13-20 days total. Both parents help with incubation (Hughes 2020). Additionally, pairs may have younger males that assist (USFWS 2014; Hughes 2020). The degree of contribution from colony incubation is a data gap, both in terms of level of effort and in terms of genetics. There are data showing that different males and females may genetically contribute to eggs in the same brood (McNeil 2015).

YBCU are opportunistic feeders. They mainly eat large insects, but also prey on small lizards and amphibians. They require a large amount of food, especially as nestlings. Both parents feed and brood the young equally, and nestlings transition to the fledgling stage by day 7-9. Once they become juveniles, both parents and the young leave the nest patch after a day. YBCU may lay second and even third clutches, sometimes with different partners (USFWS 2014).

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[4] The USFWS received a petition to delist the Western DPS, and there is currently a species status assessment underway with anticipated findings later in 2020

Like with SWFL, little is known about YBCU life history once the young reach the juvenile stage. The YBCU leave for their fall migration beginning in early-late August, with most birds departing by mid-September (Sechrist 2012; Hughes 2020).

AVIAN SPECIES CONCEPTUAL ECOLOGICAL MODEL DESCRIPTION

The two avian CEMs were developed were developed in tandem and both focused on life stages, with each depicted as a bulls-eye graphic divided into wedges. Each wedge represents a driver or stressor at that life stage for the species. A driver is a variable that is beneficial to the species at a specific life stage and contributes to species success. A stressor is a variable that negatively impacts the species at a specific life stage and contributes to species failure, including mortality. The bulls-eyes also depicts the level of importance of each variable, the ability to manage the variable, and if there are high level uncertainties related to the variable. The relative size of each variable's wedge is not indicative of any importance (Figure C2).

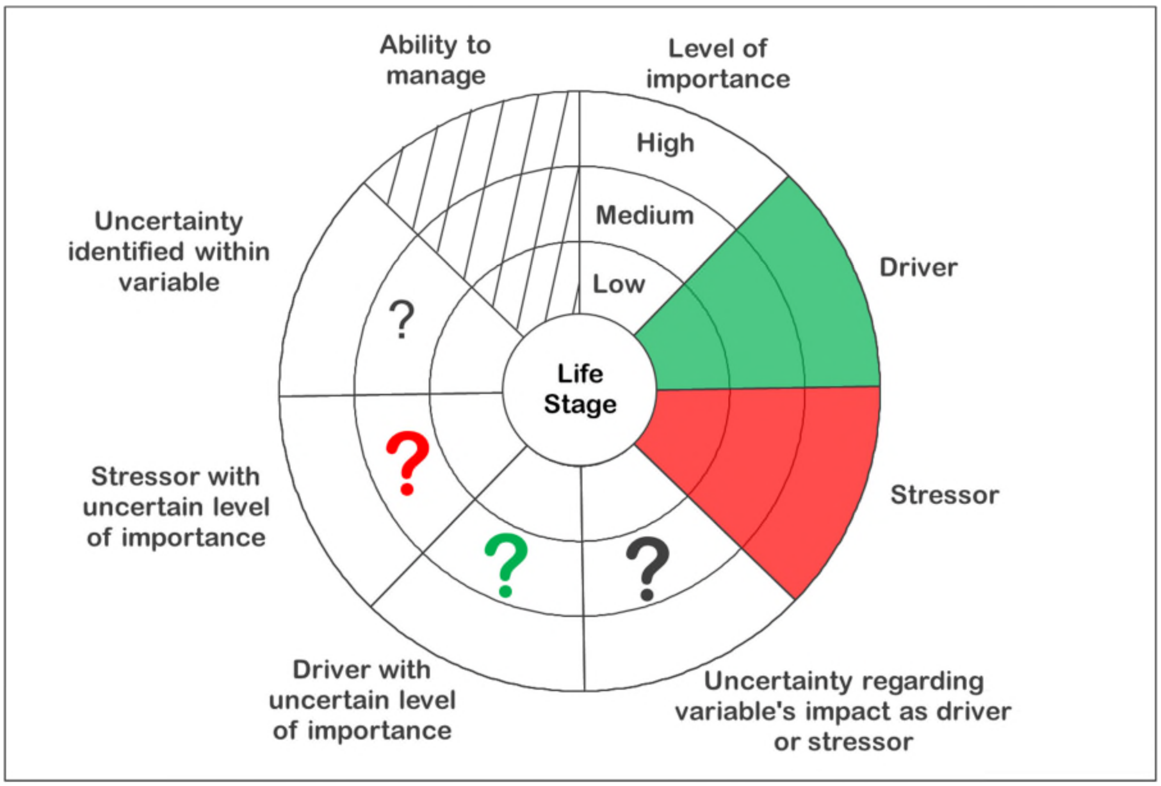

Figure C2. Avian Conceptual Ecological Model Legend

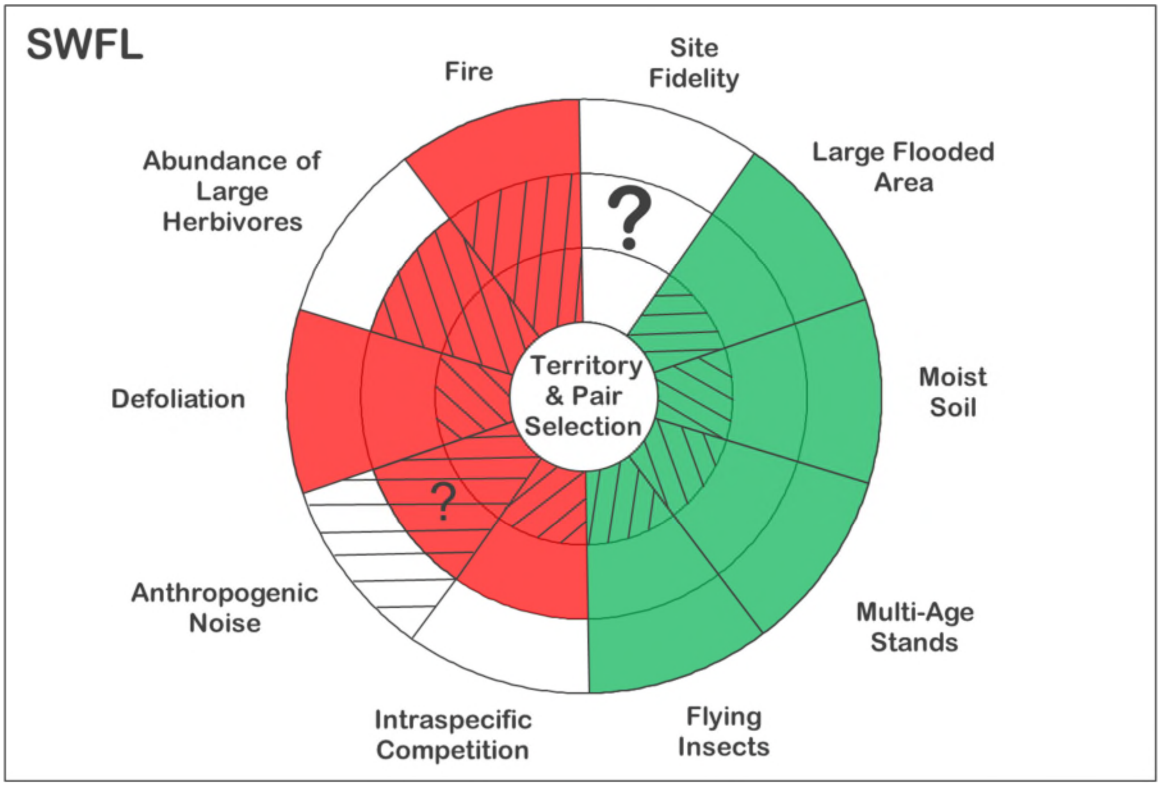

Figure C3. Southwestern Willow Flycatcher Territory and Pair Selection Life Stage.

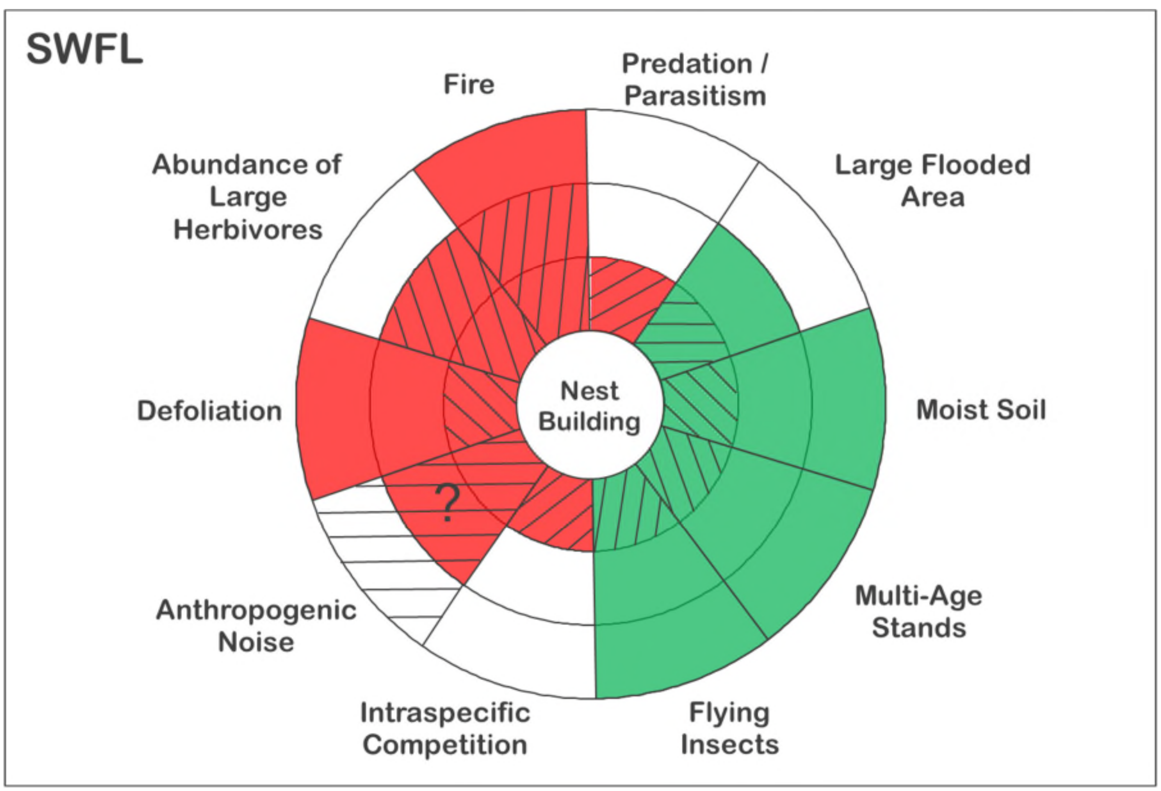

Figure C4. Southwestern Willow Flycatcher Nest Building Life Stage

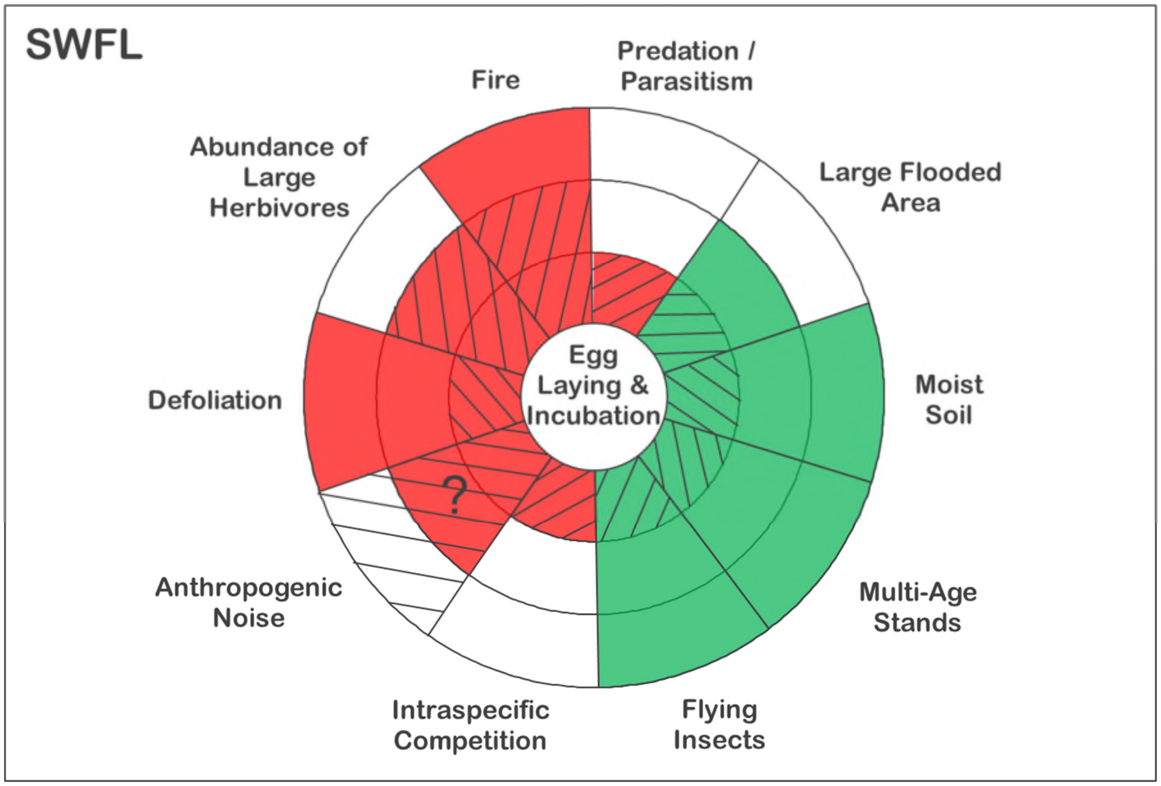

Figure C5. Southwestern Willow Flycatcher Egg Laying and Incubation Life Stage

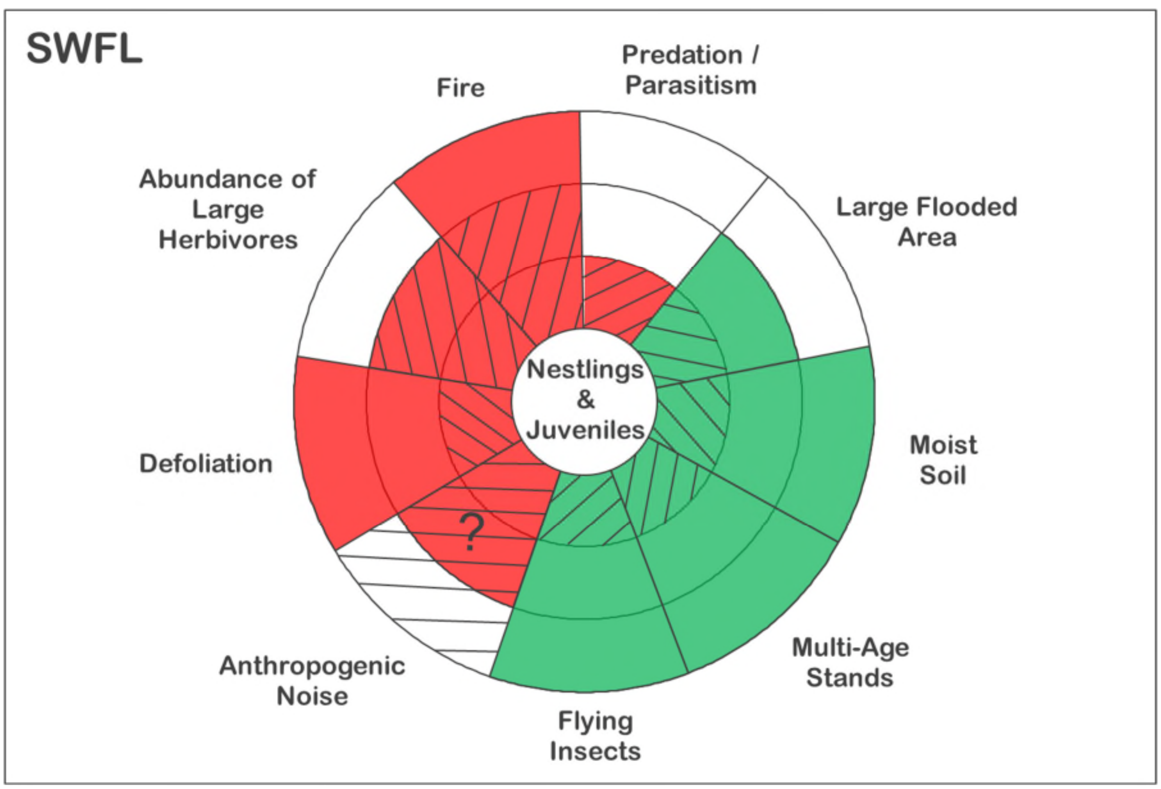

Figure C6. Southwestern Willow Flycatcher Nestlings and Juveniles Life Stage

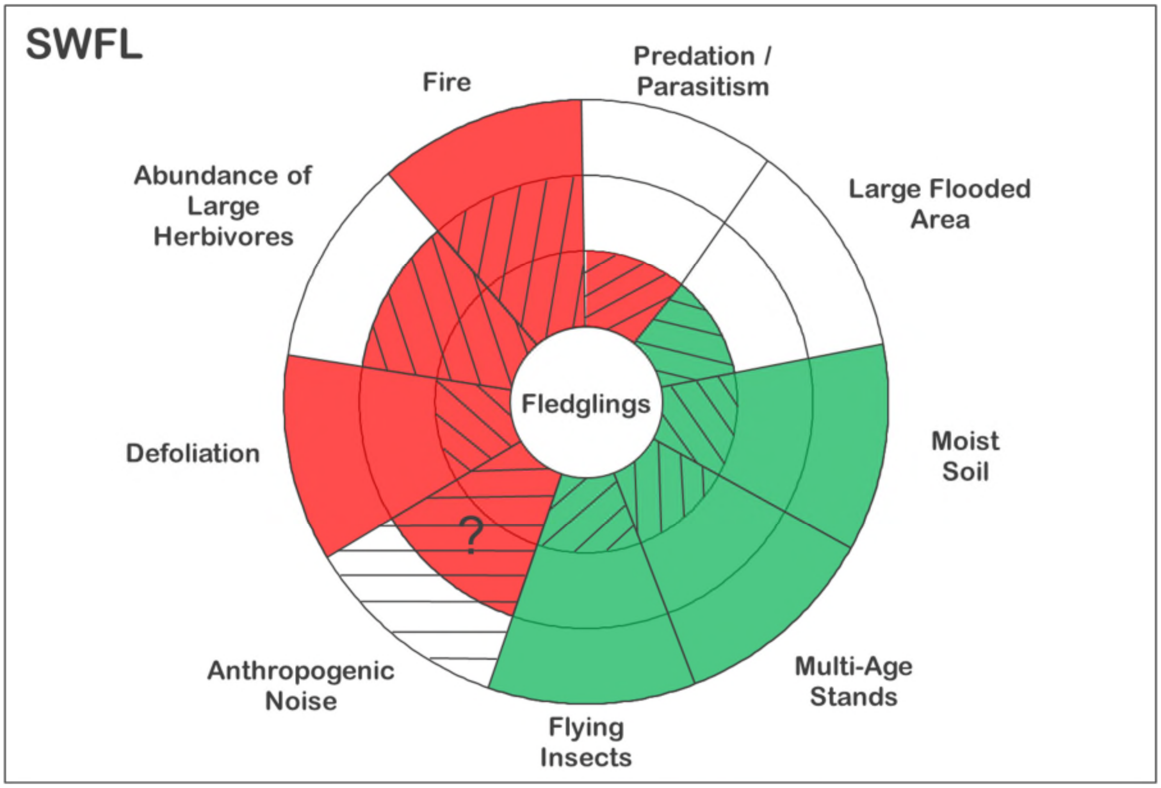

Figure C7. Southwestern Willow Flycatcher Fledglings Life Stage

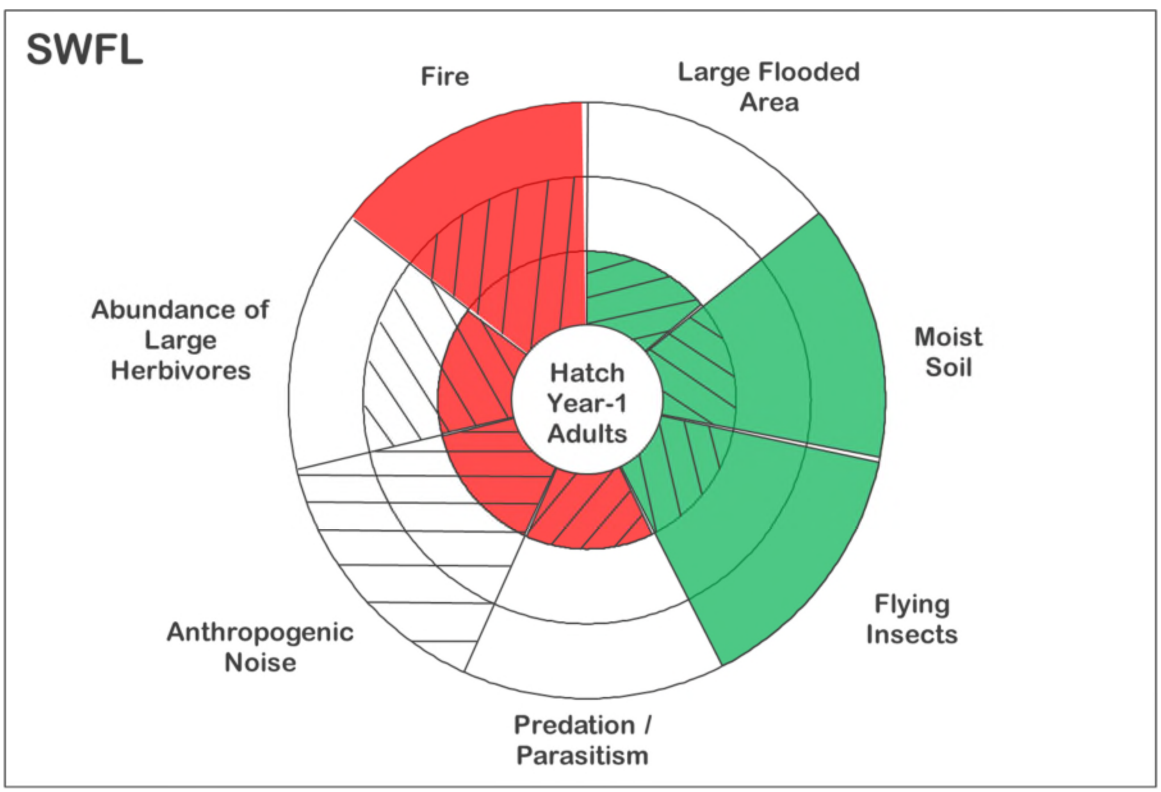

Figure C8. Southwestern Willow Flycatcher Hatch Year-1 Adults Life Stage

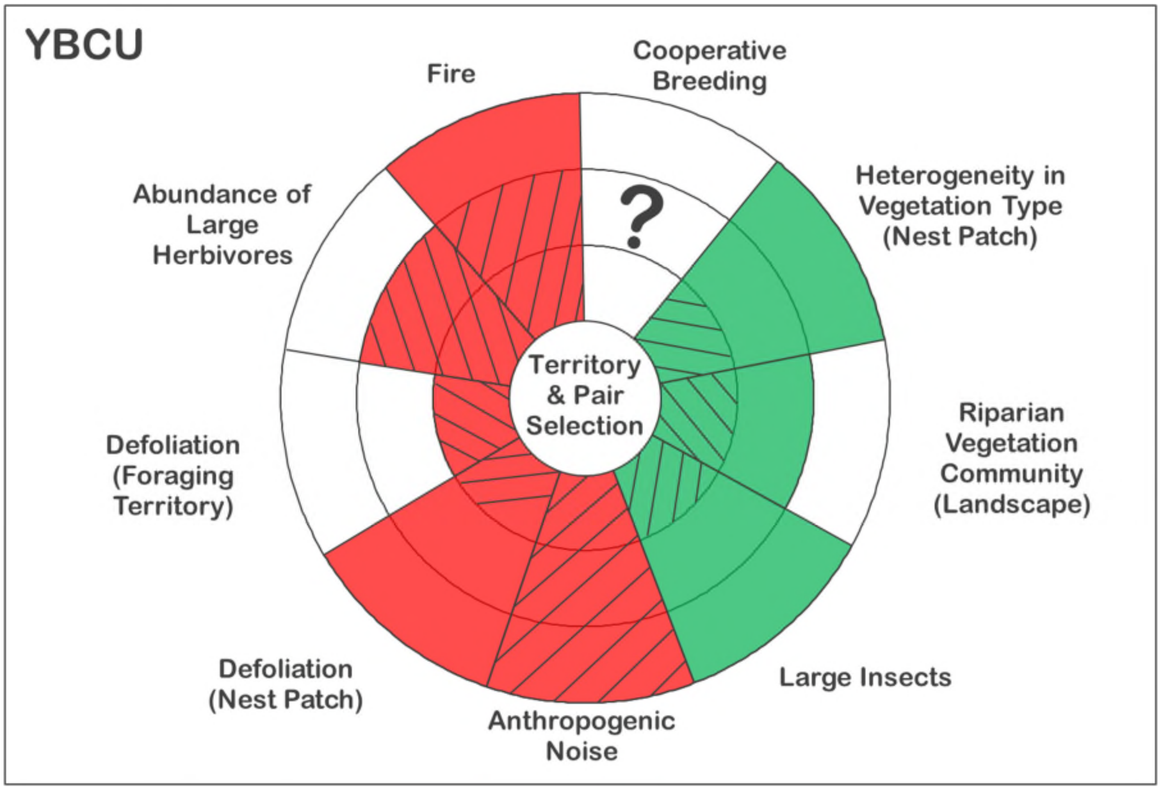

Figure C9. Yellow-Billed Cuckoo Territory and Pair Selection Life Stage

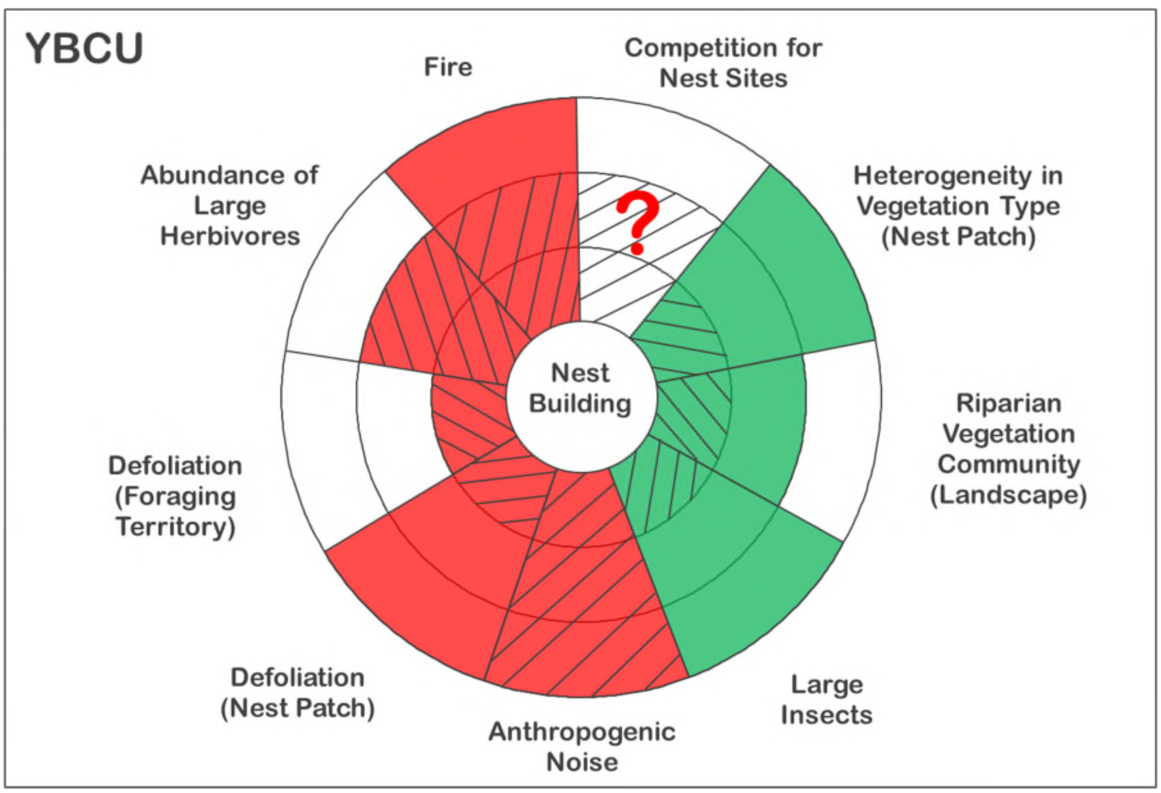

Figure C10. Yellow-Billed Cuckoo Nest Building Life Stage

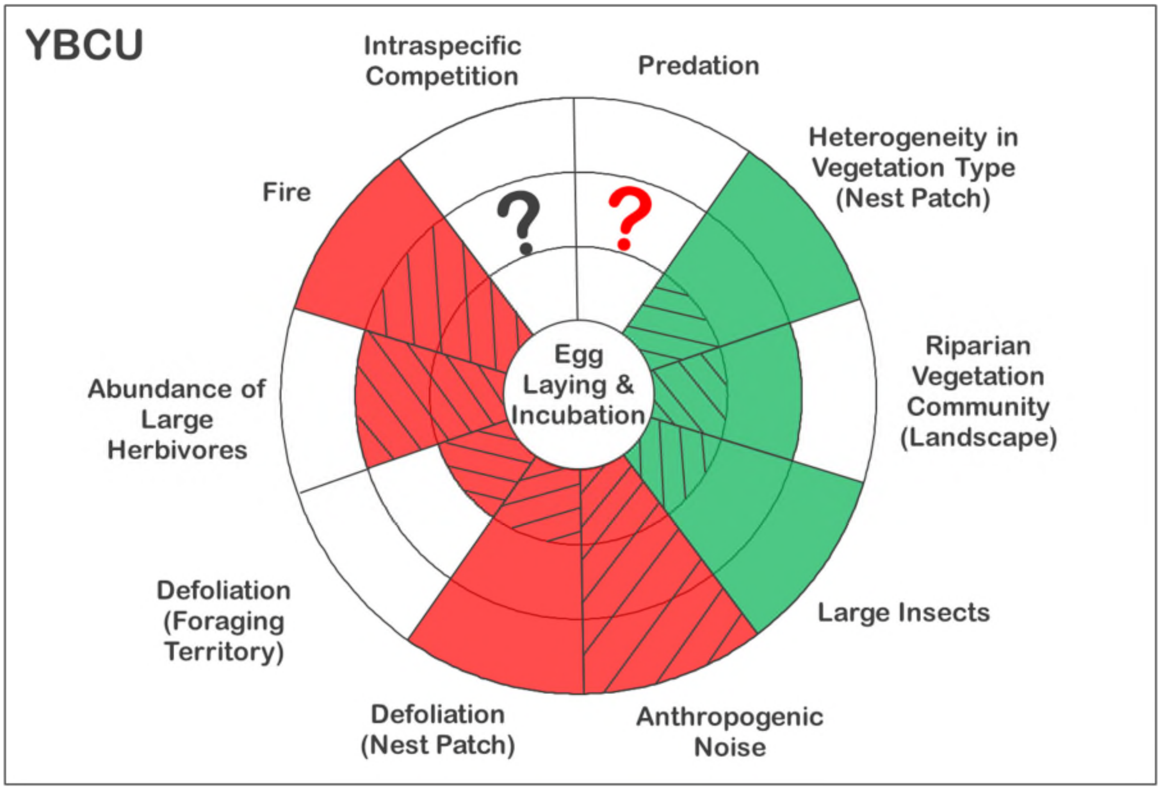

Figure C11. Yellow-Billed Cuckoo Egg Laying and Incubation Life Stage

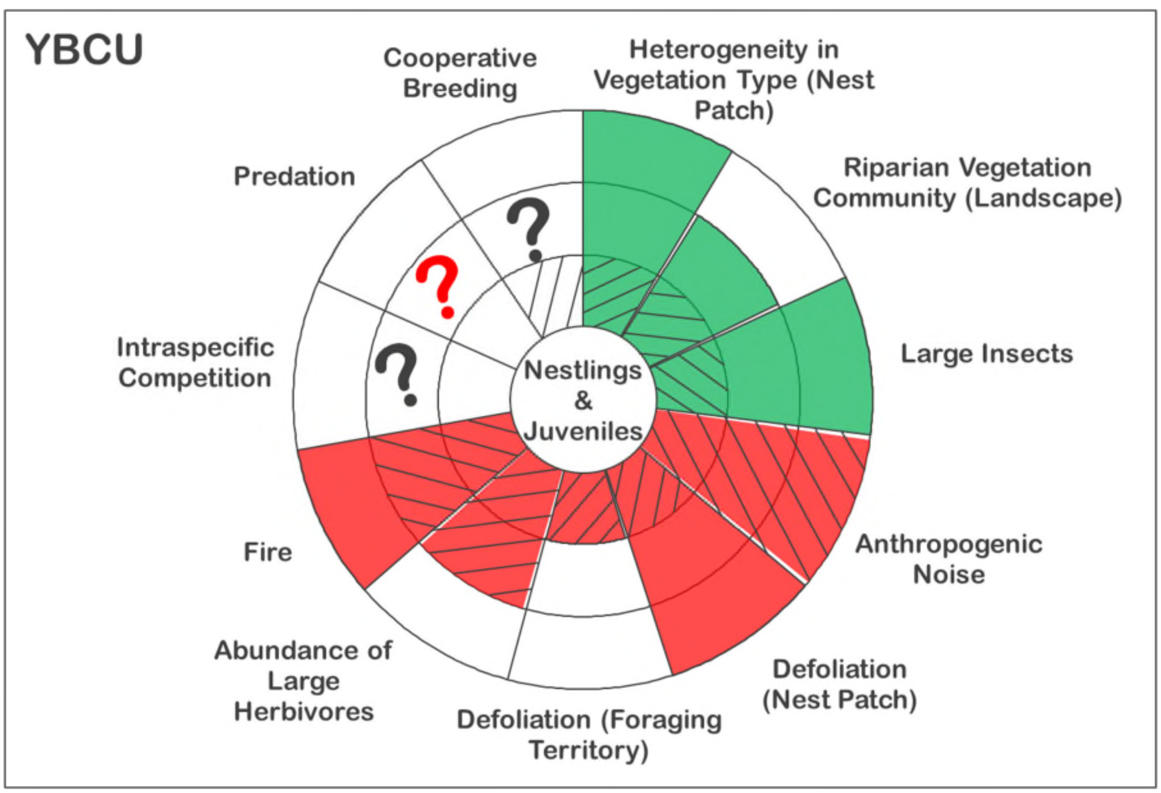

Figure C12. Yellow-Billed Cuckoo Nestlings and Juveniles Life Stage

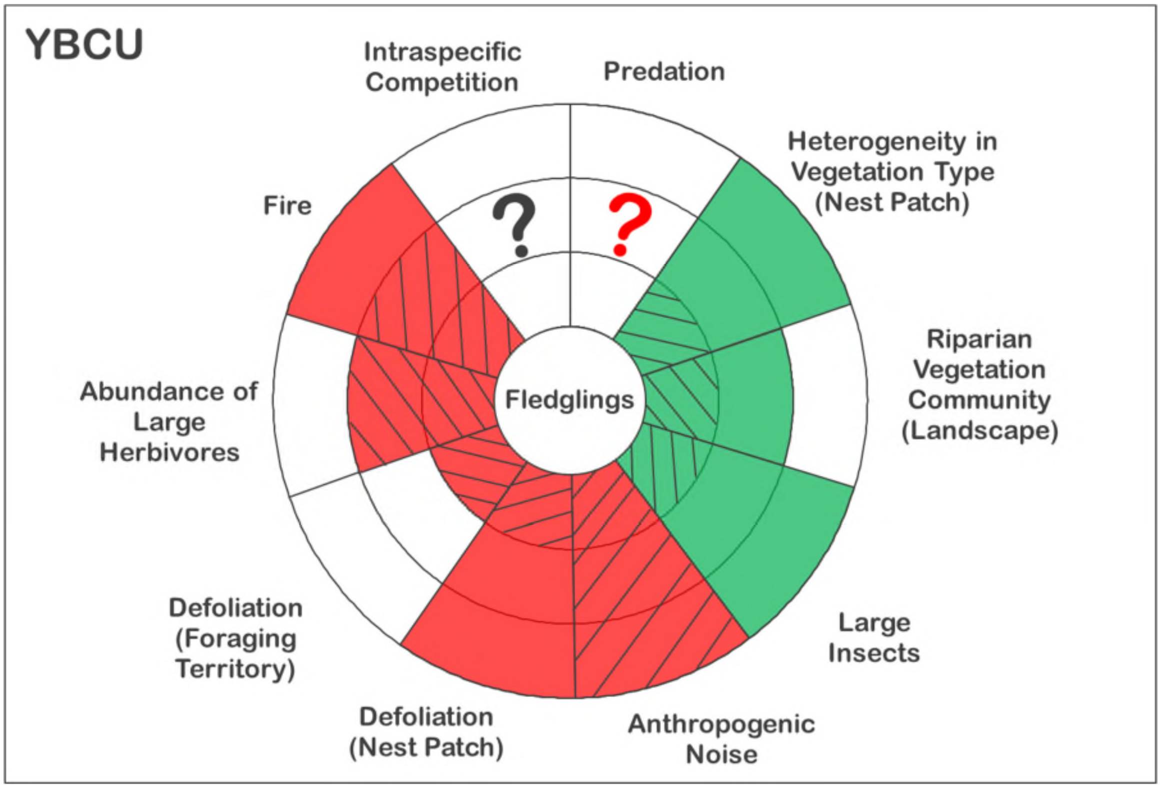

Figure C13. Yellow-Billed Cuckoo Fledglings Life Stage

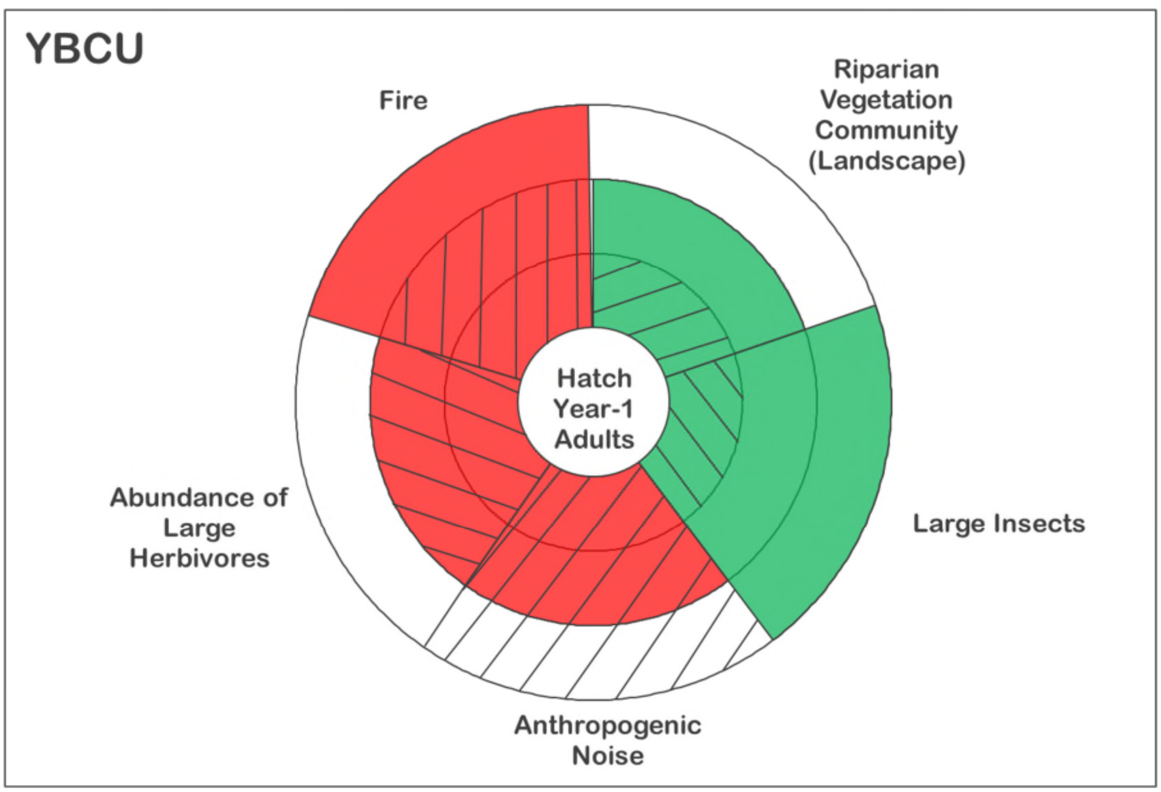

Figure C14. Yellow-Billed Cuckoo Hatch Year-1 Adults Life Stage

AVIAN CONCEPTUAL ECOLOGICAL MODELS LIFE STAGES DEFINITIONS

Migration and Overwintering

SWFL

Northbound Migration: SWFL are late spring migrants with arrival dates in Arizona as early as 3 May (Phillips et al. 1964) and from second week of May to mid-Jun in California (Small 1994). Captures during spring migration occurred in the central Rio Grande valley of New Mexico occurred between May 13 and June 8 with a peak in the first week of June, but varied by site and year (Yong and Finch 1997). Habitat used during spring migration is likely similar to that described for fall. In New Mexico, the willow flycatcher is known to migrate regularly along the Rio Grande (Yong and Finch 1997) and the Pecos River (Hubbard 1987), and occurs regularly as a migrant in the southwestern-most desert region and the eastern-most plains region of the state (Hubbard 1987). Migration requires high energy expenditures, exposure to predators, and successful foraging in unfamiliar areas. Therefore, migration is the period of highest mortality within the annual cycle of the flycatcher (Paxton et al. 2007). Willow Flycatchers of all subspecies sing during northward migration, perhaps to establish temporary territories for short-term defense of food resources.

Southbound Migration: Fall migration begins when adult birds depart from their breeding territories, generally in early to mid-August, but some birds may stay until mid-September if they fledged young late in the season (Phillips et al. 1964, Yong and Finch 1997). Unpaired males that fail to attract a mate and pairs that repeatedly lose nests to nest parasitism or predation may leave territories by early July. Fledglings leave the breeding areas a week or two after adults, likely because young birds' pre-basic molt occurs on breeding grounds (adding to the length of their stay), whereas adults delay pre-basic molt until they reach wintering grounds (Unitt 1987, Yong and Finch 1997). Habitat use during migration is similar to breeding habitat, including riparian woodlands with open overstory and dense mid- and low-stories, and adjacent agricultural fields, with close proximity to water. The highest capture rates in one study along the Middle Rio Grande occurred within willow habitat, followed by dense young cottonwood-Russian olive stands. Affinity for willow habitat and higher body mass recorded in this habitat is likely due to higher densities of arthropods (McCabe 1991, Yong and Finch 1997). Mass gain of recaptured birds suggest stopover to replenish fat stores during migration is necessary for this species (Yong and Finch 1997). In New Mexico, birds are known to migrate regularly along the Rio Grande (Yong and Finch 1997).

Overwinter: The Pacific lowlands of Costa Rica, as well as other regions of Central America seem to be the most important wintering grounds for the *extimus* subspecies based on genetic data (Paxton et al. 2011). On the wintering grounds, flycatchers use habitat with standing or slow-moving water and/or saturated soils, patches of trees, woody shrubs, seasonally inundated floodplains with emergent vegetation, pastures, and open areas, often within agricultural landscapes (Lynn et al. 2003, Schuetz et al. 2007). The presence of water or saturated soils seems to be more important than vegetative structure (Schuetz et al. 2007). Individuals defend territories throughout the winter and show high fidelity to wintering territories (Koronkiewcz et al. 2006, Sogge et al. 2007). Survivorship is thought to be high over the wintering period

(Koronkiewcz et al. 2006). Threats on the wintering grounds include human-driven disturbance, such as mining and logging, as well as grazing by domestic livestock (Schuetz et al. 2007)

YBCU

Migratory routes of western yellow-billed cuckoos are not well known because few specimens collected on wintering grounds have been assigned to western or eastern populations. Western cuckoos depart 2–3 weeks earlier than eastern cuckoos (Hughes 2020). Departures begin in early to late August with most birds gone by mid-September, though some may depart later (Hughes 2020, McNeil et al, 2011).

Most information on migratory routes is based on two birds fitted with geolocators. Both birds suggested a loop migrations route with distances between 9,500-9,900 km. The first recaptured bird migrated south through Central America to winter in portions of Bolivia, Brazil, Paraguay, and Argentina (Sechrist et al. 2012). The second bird passed through the Caribbean region, and wintered from mid-November to late April in the Gran Chaco of central South America, near the borders of Paraguay, Bolivia, and Argentina (McNeil et al. 2015).

Spring migration routes differed for both birds, the first bird migrated north through the Caribbean, and moved between New Mexico and Mexico at the end of summer in 2009 and again in 2010 before being recaptured at its breeding site. The second bird passed through Peru and Central America on its way north (McNeil et al. 2015). This bird also appeared to pause in southern Arizona or Sonora before and after migration, paralleling the first tracked bird. Data from these two birds show dynamic migration strategies, and suggest the monsoonal region may be important to the western population during the migratory stages of the life cycle.

Western cuckoos arrive on breeding grounds starting mid- to late May, 4–8 weeks later than eastern cuckoos occurring at same latitude (Franzreb and Laymon 1993). Considerable numbers are usually not present until early to mid-Jun, and transients continue to travel through late June to mid-July (Hughes 2020).
Little information exists for habitat use during migration. Western cuckoos may migrate north along greening riparian corridors and surrounding landscapes following monsoon precipitation (Wallace et al. 2013).

Territory and Mate Selection

This life cycle stage occurs upon the adult birds' arrival to the breeding ground where they must choose a mate and select a breeding territory. Birds choose a territory that can provide food, water, shelter, and nesting sites.

SWFL

Little information exists on SWFL pair selection. Studies on other Empidonax species indicate that pairs form using coordinated movements and sounds (Tarof and Ratcliffe 2000). Female SWFLs ultimately select the nest site.

YBCU

There is even less information on YBCU pair selection. Pairs may visit potential nest sites together frequently prior to building the nest.

Nest Building

Nest building occurs when a bird or a mated pair is actively building a nest before egg-laying begins. Nest building within the territory usually begins within a week or two after pair formation. Nest building is an energetically expensive activity for birds (Mainwaring and Hartley 2013).

SWFL

The female SWFL builds a nest over the course of 5-7 days without help from the male. The nest begins with a platform of grass or strips of vegetation, and the female weaves grass onto the surrounding vegetation to form a cup using her beak and her body.

YBCU

Both the male and female YBCU build the nest over the course of several days. The nest is placed on a horizontal branch or fork of a tree and is constructed from small twigs, pine needles, and similar material.

Egg-Laying and Incubation

Egg laying generally begins from mid-May through mid-June, depending on the geographic area and elevation. This life cycle stage begins when females are actively laying eggs followed by incubation until all eggs hatch. The energetic cost of egg production and incubation for female birds is poorly understood.

SWFL

SWFLs lay 3-4 eggs per clutch. Generally, one egg is laid per day with one day skipped, so the egg laying period takes between 4 and 5 days. Eggs hatch in 12-14 days, so the entire egg laying and incubation period is between 16 and 20 days, on average. Males do not assist with incubation.

YBCU

Cuckoo females can lay between 1-5 eggs in a clutch, but usually 2-3. Usually cuckoos lay one egg every other day, but females may wait up to 5 days between eggs. Eggs hatch in 9-11 days and male and female share incubation duties. Helper males may assist with incubation. YBCU start incubation as soon as the first egg is laid, often resulting in nestlings of different ages in the same nest. YBCU egg laying and incubation period can be quite variable, between 13-20 days.

Uncertainty: Colony incubation/helping. Who contributes to eggs, who contributes to incubation?

Nestlings

This is the life cycle stage that occurs from the time the first egg hatches until the young leave the nest. The nestling state is very energetically costly for flycatcher parents, who bring food to the nestlings up to

22 times per hour. This is a very vulnerable state for the nestlings, as they are very susceptible to predation, and for the adult parents as they are expending energy to forage and protect the nest.

SWFL

Female SWFL do the majority of brooding and feeding the young, but males do play a role in food provisioning. The nestling period lasts around 14-15 days.

YBCU

Growth is extremely rapid for YBCU nestlings – as short at 17 days from the start of incubation to fledging which is among the shortest of any bird species. Both parents brood and feed the young equally. Occasionally, a nonparent adult or “helper” bird will assist with caring for nestlings. YBCU nestlings have mostly fledged and start to venture away from the nest by day 8.

Fledglings

This life cycle stage occurs after young birds leave the nest, but before they are fully independent from the parents. Studies on fledgling survival for most bird species are lacking.

SWFL

SWFL young are capable of short (30 meter) flights at the time they leave the nest. SWFL young huddle together for 3-4 days after leaving the nest and remain on the adults’ territory for around 14 days before dispersing.

YBCU

Cuckoo young leave the nest at 7-9 days and both parents and young leave the vicinity of the nest after one day.

Data Gap

What happens between fledgling and when they leave for full migration? Some indication may be vulnerable once they fledge, but no monitoring data.

Juveniles

This life cycle stage occurs after the young have left the parents’ territory and no longer depend on their parents for food.

SWFL

For SWFLs, broods probably break up once the young enter this life cycle stage as flocking of immature SWFLs has not been reported.

YBCU

There is little information for cuckoos in this immature stage.

SOUTHWESTERN WILLOW FLYCATCHER AND YELLOW-BILLED CUCKOO CONCEPTUAL ECOLOGICAL MODEL GLOSSARY

Note that the size of the wedges on the life stage charts of the conceptual ecological models do not hold any significance. They are simply a product of the number of variables included in each life stage.

Abundance of Large Herbivores

This variable includes both domesticated animals, such as cattle, and wild animals, such as elk, beavers, and feral hogs. Grazing and browsing from domesticated and wild herbivores can negatively impact the success of restoration sites and SWFL and YBCU nesting sites by stripping trees, knocking down vegetation, compacting soil, and causing erosion. Additionally, a growing herbivore population can also attract more predators, which increases trails that negatively impact SWFL and YBCU habitat.

Stressful environmental conditions, such as drought, exacerbate the negative impact of grazing, even when there is no increase in the herbivore population.

Properly managed herbivore populations could provide some benefit by increasing soil nutrients. In the short term, the large herbivore population could negatively impact water quality by trampling vegetation at the water's edge, which often contains riparian plant species that are important for SWFL nesting habitat.

YBCU

Because YBCUs have long-distance vision and have large home ranges, they may benefit from edge effects near agricultural areas, which may have greater food availability.

Anthropogenic Noise

Anthropogenic noise can negatively impact SWFL and YBCU communication and nest success. This could hinder pair selection and, if the noise impact is too great, lead to nest abandonment. There are uncertainties related to the influence of the timing, duration, and constancy of noise, as well as distance from the noise source, affect the degree of impact. Introduced noise may be less critical once nestlings have fledged; however, the lack of monitoring after fledging has led to uncertainties around this.

SWFL

There is an unpublished study at the Bosque del Apache National Wildlife Refuge on the impact mowing has on nests. Observations revealed that SWFL adults were initially defensive but began following the mowers when insect activity increased.

YBCU

YBCUs have large territories, so they might communicate over long distances. This may mean that they are greatly impacted by noise.

There is published literature that indicates YBCU vocalization frequency overlaps with the frequency of constant traffic, which results in communication interference. YBCUs have been observed to avoid high-traffic areas, and may even select lower quality habitat in order to avoid traffic noise. (Goodwin and Shriver 2011)

Cooperative Breeding

YBCU are known to form colonies. Young juvenile males will act as "helper males" within a nest and help with feeding and incubation. A genetic study in Arizona found that eggs in the same nest had varied genetic parentage (McNiel 2015). There are many uncertainties around the degree to which colony size and cooperation contribute to nest success and to the genetic success of the population as a whole. Researchers may be overestimating the number of YBCU territories as a result of the colony nature of these birds.

Defoliation

Defoliation increases the predation risk and negatively impacts the microclimate needed for nest success. Causes of defoliation include the tamarisk leaf beetle, drought, fire, and tree senescence.

Defoliation that occurs during the breeding season will have different impacts than defoliation that occurs between seasons. During the breeding season, defoliation may cause failure of existing nests. Defoliation that occurs before territory selection decreases habitat availability, as, SWFL and YBCU pairs are less likely to build nests in the affected areas.

YBCU

Given the larger range of YBCU, defoliation effects on the species will be different at the nest patch scale compared to the larger foraging territory scale. Defoliation away from the nest patch and in the foraging territory will impact food availability. However, as the foraging territory of the YBCU is so large, impact may be minimal unless there is wide-spread defoliation. Defoliation of this magnitude can be caused by tamarisk leaf beetle, high intensity fire, drought, tree over-maturity, or overgrazing. If defoliation is localized, YBCUs can forage in other areas.

Fire

Depending on the intensity, fire can negatively impact riparian habitat, as it reduces short-term and long-term habitat availability. In the case of a catastrophic fire, sterilized soil may limit vegetation regrowth. In areas where the water table has been lowered due to water diversions, the historic riparian plant community may be unable to recover after a catastrophic fire and will transition to an upland or shrubland state. However, prescribed burns have been used to spur native plant rejuvenation and can produce post-fire soil benefits. Increase in leaf litter following defoliation can increase fire intensity. Non-native species and altered hydrology also alter fire behavior. More fire studies in riparian areas are needed.

Flying insects

SWFLs mainly prey on flying insects, such as mosquitoes. These insects require slow-moving and/or standing water. Thus, abundant standing water is required to provide adequate insect prey. Pesticide use, defoliation, drought, and other factors that dry out soil negatively impact insect populations.

Heterogeneity in vegetation type (nest patch)

YBCUs require a nest patch size of over five hectares with 50-75% mid-story cover that is 3-10 meters high. Canopy cover is critical at the nest patch scale. (USFWS 2014; Johnson 2020)

Intraspecific competition

There are many uncertainties around how much intraspecific competition affects SWFL and YBCU breeding success. A site's ecological carrying capacity may be dependent on food availability.

SWFL

SWFLs generally have a 20-40 meter foraging patch size. However, multiple SWFLs may use high quality habitat patches, creating a high population density. SWFL pairs tend to spread out when adequate habitat is available, or when new habitat patches become available on the landscape; possibly as a result of lower food availability during early patch establishment.

YBCU

YBCU may compete amongst each other for nest sites and food sources, and is the degree of competitive interactions is unknown. Competition may include intraspecific nest parasitism, which may be common in this species (McNiel 2015).

Proximity to Water

Large flooded areas result in low velocity flow of shallow depth underneath the nest. This contributes to the insect populations that make up the prey base for SWFL and YBCU, is beneficial for plant health, and facilitates the cooler microclimate needed for nest success.

Moist soil underneath the nest is vital for maintaining the microclimate needed for nest success. Additionally, moist soil boosts insect populations, plant health, and seed establishment.

SWFL

During migration, SWFLs have been observed to be attracted to large flooded areas.

Large Insects

YBCUs are opportunistic feeders that feed on large insects and small lizards. They require a large amount of food, especially when they are young. YBCU young grow rapidly and fledge in seven days. YBCUs may choose territory based on insect outbreaks. Pesticide use, drought, and defoliation negatively impact their prey base.

Multi-Age Stands

SWFL breeding pairs prefer multi-age vegetation stands with 50-75% mid-story cover and dense cover that is 3-6 meters high. Dense vegetation provides protection from predators and contributes to the cooler microclimate of the nest site.

Nest Parasitism & Nest Predation

SWFL and YBCU nest predators include snakes, raccoons, skunks, rodents, and other birds. Loss of vegetative cover, drought, and other stressors can lead to predation and parasitism. There are uncertainties around how much edge effects impact parasitism and predation.

SWFL

Cowbirds are known to parasitize SWFL nests. Cowbird abundance, and therefore parasitism, tends to be a function of habitat type and quality, and the availability of suitable hosts, not specific to the flycatcher. Data show that predation and parasitism balance out to about the same total combined level every year.

YBCU

YBCU tend to be quiet around their nests, so as not to attract predators. Loss of canopy cover, drought, and other stressors can increase predation risk.

Riparian Vegetation Community (Landscape)

YBCUs require large expanses of riparian habitat at the landscape level with a mosaic of different vegetation types for both the nest patch and the foraging areas. The estimated home-range size of the YBCU is between 62-91 hectares (Sechrist et al. 2013; Dillon and Moore 2020).

Site Fidelity

SWFL site fidelity can both negatively or positively influence reproductive success, depending on site health and other characteristics. There are uncertainties around the degree of SWFLs site fidelity and what might influence dispersal to another site.

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Report	Page Number	Recommendation Number	Recommendation	Panel Priority	MRGESCP Original Priority	MRGESCP Current Priority	Comments	Status	Verification
Fraser et al. 2016	4	Reporting Rec. 1	Sometimes it is not clear how Ne estimators relate to purpose. The reports could improve the explanations for why certain approaches were adopted.	1	0			Osborne et al. report now using different estimators and explaining them (2017 report)	Osborne et al. 2017
Fraser et al. 2016	4	Reporting Rec. 2	Develop a biological relevant and realistic benchmark for critically low levels of genetic diversity. One possible way to set a benchmark would be to estimate the 95% confidence interval (CI) for genetic diversity (expected heterozygosity [He] and number of alleles [Na]) using all samples across time and space. If the diversity falls below the CI, then more aggressive management actions may be warranted.	1	0			Osborne et al. reported a 95% confidence interval in her 2017 report.	Osborne et al. 2017
Fraser et al. 2016	4	Reporting Rec. 3	There needs to be a clear statement of the hypothesis and predictions being tested. For example, a simple hypothesis is whether there is a difference in estimates of genetic diversity between the pre- and post-augmentation periods. If this is the case, one approach would be to use a linear model to compare the estimates pre- and post- augmentation. Although time should be included as a co-variate, there is no effect of augmentation on observed heterozygosity corrected for sample size (Hoc) ($t = 1.95$, $p = 0.071$).	2	0				
Fraser et al. 2016	4	Reporting Rec. 4	The authors need to redefine pre-augmentation (1987, 1999) and augmentation periods (post 1999) given the augmentation that took place in 2000 and 2001. They may not be able to conclude strongly whether genetic diversity of the natural spawning population has changed. However, the authors can say that augmentation has maintained genetic diversity throughout the augmentation period, with the provision that this conclusion is based on the nine microsatellite loci evaluated, which might not reflect genome-wide variation.	2	0				
Fraser et al. 2016	4	Reporting Rec. 5	Microsatellite loci may no longer be the most effective markers for the purpose as the cost of newer, genotyping-by-sequencing (GBS) approaches has become more affordable for largescale throughput of many individuals. The limitations of microsatellites relative to other genetic markers such as single nucleotide polymorphisms (SNPs), and trade-offs associated with different genetic markers in relation to RGSM genetic monitoring goals, are discussed in detail under Questions 2, 8, 9, 10, and 13 (particularly 13).	2	0			The high through-put markers SOW is currently in contracting.	Contracted in 2018
Fraser et al. 2016	4	Reporting Rec. 6	The Genetic Project PIs may also wish to examine genetic diversity / Ne variation over time using a piecewise regression as these can be used to find any breakpoints in the data; also referred to as segmented regression. If a breakpoint is identified say for pre- versus post-augmentation, then separate regressions can be run for each section. This approach can also identify points in time where there are temporal changes in genetic diversity.	3	0				

Fraser et al. 2016	16	Question 13 Rec. 1a	The panel therefore recommends that both neutral and adaptive genetic variation be monitored over time in RGSM in the future using a larger, more diverse set of genetic markers. Genotyping-by-sequencing (GBS) or related equivalent would provide more confident estimates of genome-wide neutral genetic variation (Nac, Ho) in RGSM because it would more likely represent the entire genome (for more information on GBS and related NGS approaches and their practical benefits for conservation genetics monitoring, see the review of Allendorf et al. 2010)...thus we recommend examining phenotypic variation for important life history traits (size/age maturity, growth rate), behavioral traits (anti-predator behavior, risking taking behavioral syndromes) and morphology (body shape as it relates to flow regime).	2	0			The high through-put markers SOW is currently in contracting.	Contracted in 2018
Fraser et al. 2016	17	Question 13 Rec. 1b	Sampling of floodplains should be considered and included where feasible to ensure that the genetic characteristics of RGSM are adequately represented in egg collection samples.	1	0			SOW description developed	2018
Fraser et al. 2016	18	Question 13 Rec. 2a	Conduct random sampling of annual egg collections from nature, to include not only the main channel but also the floodplains, for subsequent hatchery rearing (e.g., current collections only come from the main channel of the Rio Grande River, not on floodplains).	1	0			SOW description developed	2018
Fraser et al. 2016	18	Question 13 Rec. 2b	Rear RGSM in environmental conditions that resemble natural environmental conditions as much as possible. This will reduce relaxation of selection or non-random survival at egg/early life stages in relation to habitat selection/settlement, behavioral/physiological characteristics, anti-predator responses etc. Specific recommendations for RGSM hatcheries include: (i) early juvenile environmental enrichment that resembles critical floodplain habitat (temperature, substrate, flow, turbidity, pH, conductivity, food sources, natural daylight); and (ii) some exposure to natural predators, or at the very least, mimicking of predators to stimulate anti-predator conditioning.	1	0			The BioPark and Dexter raises RGSM on natural foods as much as possible, and some outside. Ponds at Los Lunas and in Dexter are exposed to predators. Will need additional documentation from the facilities to determine what the characteristics are at each facility (diatoms, predator exposure, other environmental conditions). Gut analysis and stable isotope analysis done as well. SOW description developed.	2018
Fraser et al. 2016	18	Question 13 Rec. 2c	RGSM live longer in captivity and the breeding program uses 4-year old fish as brood stock. By contrast, in the wild the breeding population is comprised largely of 1-year old fish. Thus, it will be prudent to evaluate the phenotypic effects of older brood-stock. Also, because larger fish have about 4x as many eggs as younger adults (10,000 vs. 2,500), and there is also likely higher variance in egg production among 4-year old fish compared to the variation in egg production among 1-year old fish. This could undermine efforts to equalize family sizes. Thus, using younger fish as brood stock will reduce the likelihood of un-intentional domestication selection, and also result in higher effective population sizes (due to reduced variance in egg production among females).	1	0			Dexter does not use 4 year old fish anymore; documented in their annual report. BioPark does not use 4 year old fish.	2017

Fraser et al. 2016	18	Question 13 Rec. 2d	Equalize contributions of different adults in the captive broodstock to new broods/lots as much as possible.	1	0			Not currently possible. Requires a change in spawning protocol. Communal spawning vs. pairwise spawning (having the SNP's developed will enable this to become a SOW).	
Fraser et al. 2016	18	Question 13 Rec. 2e	Rear RGSM so as to maintain the growth trajectories typical of wild-raised fish (i.e., Age 1 fish in captivity should exhibit the same range of sizes of Age 1 fish in the wild). At present, either faster growing individuals may be unintentionally selected for, or other fish phenotypes (e.g., size, condition, body shape) may not match natural sizes upon release.	1	0			First cut would be to have each facility provide fish length distributions for each age class of fish. Compare to lengths observed on the river. This could be a modifcation to current contracts. Additional phenotypic or behavioral comparisons would be a SOW.	
Fraser et al. 2016	19	Question 13 Rec. 2f	Rear RGSM on natural diet if possible; diet appears natural at early life stages, but diet appears supplemented in later life stages (pellet feed).	1	0			The BioPark, Dexter, and Los Lunas raise RGSM on natural foods as much as possible, and some outside.	Personal communication 2018
Fraser et al. 2016	19	Question 13 Rec. 2g	Minimize the duration in captivity as much as possible before release; domestication selection is reduced with less captive exposure (see Frankham 2008 and Fraser 2008).	1	0			Release is currently as early as possible. USFWS is currently examining the effectiveness of a February release.	February release study underway in 2018
Fraser et al. 2016	19	Question 13 Rec. 3a	Maximize the information gained from re-stocking efforts of hatchery-raised fish back into the river in order to test particular scientific hypotheses and inform adaptive management.	2	0			Being looked at in small pieces, but too large overall to address right now comprehensively.	
Fraser et al. 2016	19	Question 13 Rec. 3b	In addition (or alternatively if resources are limited), the genetics survey could focus on characterizing whether the year classes maintained in the hatcheries change over time in their genetic constitution as a consequence of differential mortality.	2	0			SOW description developed	2018
Fraser et al. 2016	20	Question 13 Rec. 3c	Monitoring of domestication selection could include DNA fingerprinting (GBS) of wild-caught egg collections. An investigation into whether non-random changes to genome-wide variation were occurring at successive early life stages relative to the same stages in the wild would provide evidence that the hatchery environment is resulting in domestication selection.	3	0			Not currently possible. Requires the SNP study to be complete.	
Fraser et al. 2016	23	Recommendation 1	A flow chart should be constructed for each year that gives detailed numbers for: eggs and dates taken, disposition of eggs/larvae to specific rearing sites, broodstock maintained, actual breeding strategy, disposition of eggs/larvae to specific rearing sites, pooling of larvae prior to stocking, stocking sites, source of juveniles, and dates. These data should be standardized and collected for each hatchery engaged in fish production and the data should be made available electronically to all interested parties. Deviations from planned methodologies (such as the inclusion of approximately 10,000 eggs from unplanned spawning in a broodstock tank) should be noted in the flow chart.	1	0			Could do a modification to contracting to add this to the reports. May require additional funds.	

Fraser et al. 2016	23	Recommendation 2	When deviations from planned methodologies result in the production of offspring, those offspring should not be released into the wild. Release of these offspring into the river could have a negative effect on the overall genetic diversity of the population. Providing flexibility in the next recovery permit should allow such surplus fish to be properly handled, whether used for research or held until natural death in the hatchery.	1	0			Dexter uses these fish for Big Bend population. Unsure about other facilities.	Personal communication 2018
Fraser et al. 2016	23	Recommendation 3	All broodstock and sufficient subset of the pre-release juveniles should be genotyped and the contribution of each broodstock individual determined. These results can be used to gain a more accurate, precise and biologically relevant estimate of Ne for each year class. This approach avoids the inherent assumptions and excessive variance associated with the Ne estimators currently employed. This should be done every year. Developing a high throughput method would facilitate more rapid genotyping.	1	0			The broodstock from Dexter and the BioPark were genotyped, and fish to be released in the fall will be genotyped. The high throughput makers SOW is currently in contracted.	Personal communication 2018
Fraser et al. 2016	24	Recommendation 4	The Genetics Management and Propagation Plan and/or the Augmentation Plan should have a detailed methodology as to what will be done should a drought lasting more than three/four years occurs or all four year classes of broodstock are lost to a major hatchery accident.	1	0			Wade Wilson sent the DRAFT RGSM Gentics Management and Propagation Plan out on August 9, 2018	9-Aug-18
Fraser et al. 2016	24	Recommendation 5	The Science Workgroup (led by the Program) and the Genetics Workgroup (led by the USFWS) should integrate the genetics data and the decision-making more carefully. Specifically, there should be more translation of the genetics research into the adaptive management process, hatchery broodstock practices, and the integration of the past 15 years of research (genetics and ecology combined).	1	0			Will be incorporated into the AM process.	
Fraser et al. 2016	24	Recommendation 6	A more stable, consistent funding stream for the genetics research (e.g. an extended funding cycle) would ensure that all critical, temporally important genetic studies are accomplished each year (e.g., broodstock genotyping, pre-release juvenile genotyping). Cost will vary depending on the analysis and goal. At the time of writing this report, the RGSM program can expect to require approximately $50-150/individual for GBS or RAD-seq if outsourced to a genomics facility (including individual sample preparation, but not including salary for a research associate for sample preparation, data filtering and data analysis); a minimum of 30-40 individuals per year is recommended. Other genetic assessments do not require the amount of genetic data generated from GBS; any parentage assignments of offspring generating from mixed matings in the hatchery, for example, would be expected to cost approximately $5-10/individual (not including personnel salaries), and so could be (and should be) conducted on larger numbers of individuals (1000s).	1	0			MRGESCP has been able to steadily fund RGSM genetics monitoring.	
Fraser et al. 2016	24	Recommendation 7	The use of only four year fish as broodstock may compromise the maintenance of genetic diversity because of the possibility of non-random, differential survival of individuals in the hatchery. Crosses should include younger fish. As a consequence of using younger fish as broodstock with lower fecundity, more fish will be needed to produce the quota of eggs and this will increase the effective number of breeders.	1	0			Dexter does not use 4 year old fish anymore; documented in their annual report. BioPark does not use 4 year old fish.	2017

Fraser et al. 2016	24	Recommendation 8	It will be useful to conduct an evaluation of whether domestication selection is occurring in the hatcheries. This could be done using an appropriate genetic analysis and/or measuring quantitative traits to assess phenotypic variation of each captive cohort during each year in captivity.	1	0			Pheotypic aspect discussed above and genetics aspect requires SNPs to be complete.	
Fraser et al. 2016	24	Recommendation 9	We recommend the use of the term “naturally spawned” in place of the term “wild” to refer to fish captured in the river that do not have an elastomeric tag; this assumes that all augmentation fish received a tag. It is likely that all fish captured in the wild have experienced some hatchery influence in their ancestry.	2	0			Dexter has adjusted their internal terminology.	Personal communication 2018
Fraser et al. 2016	25	Recommendation 10	If possible, the augmentation team should consider artificially spawning broodstock in a one female by one male mating scheme, all the while maintaining the same total number of broodstock adults spawned (or increasing this number). This would allow equalizing family size as families are combined.	2	0			Requires SNPs to be complete.	
Fraser et al. 2016	25	Recommendation 11	Relatedness should be calculated for broodstock prior to use to choose specific crosses that avoid inbreeding. If group spawning continues, relatedness estimates could be used to ensure that potential spawners in a group have low kinship.	2	0			Requires SNPs to be complete, as well as paired vs. communal spawning work.	
Fraser et al. 2016	25	Recommendation 12	To facilitate adaptive management, experimental studies comparing the survival and reproductive success of subsets of RGSM from different stocking strategies and hatchery facilities in nature would also shed light on the extent to which domestication selection is a concern in the recovery program.	2	0			USFWS is tagging fish from different facilities and also comparing fall vs. spring release strategies. This will be a 2-3 year study. Reproductive success would be a separate SOW that will be intensive/difficult to the monitor.	USFWS intiated February release study in 2018
Fraser et al. 2016	25	Recommendation 13	A study using next-generation sequencing technology (e.g., GBS, RAD-seq) should be done with pre-augmentation samples and post-augmentation year classes to determine how the genome as a whole has changed over time. At the time of writing this report, the RGSM program can expect to require approximately $50-150/individual for such an assessment (more for RAD-seq) if outsourced to a genomics facility (including individual sample preparation, but not including salary for a research associate for sample preparation, data filtering and data analysis); a minimum of 30-40 individuals per year is recommended.	2	0			The high through-put markers SOW is currently in contracting.	Contracted in 2018
Hubert et al. 2016	28	1	Separate the catch and effort data from the small-mesh seine and the fine-mesh seine into two data sets and compute separate CPUE indices for each gear type, as well as for individual age classes captured in each gear type.	Not given	1			ASIR reported CPUE by gear type and age class in their 2017 Population Monitoring report.	2017 Population Monitoring Report, 2017 SOW with BOR

Hubert et al. 2016	28	2	The CPUE from the small-mesh seine is primarily an index of the relative abundance of a single cohort of RGSM (i.e., the most recent cohort) that is recruited into the gear late in the summer and captured into the summer of the following year. The precision of the index can be improved by exclusion of older cohorts. A separate CPUE index can be computed for older cohorts. Consider the use of length-at-age data and frequency histograms to identify cohorts.	Not given	1			ASIR addressing this recommendation using 2 length/age classes - Age 0 and Age 1+	2017 Population Monitoring Report
Hubert et al. 2016	28	3	Only larval fish should be included in the computation of CPUE indices from the fine-mesh seine because of this gear's selectivity for this life stage.	Not given	1			ASIR reported CPUE for larval fish only using the fine-mesh seine, and used the small-mesh seine for all other age classes.	2017 Population Monitoring Report, 2017 SOW with BOR
Hubert et al. 2016	28	4	An aspect of the CPUE data that warrants attention is the treatment of zero catches in data analyses. Inclusion of dry sample sites as zero CPUE values when analyzing CPUE data for RGSM in the MRG should be avoided. Field data records and the database in which the RGSM CPUE data are stored allow dry sampling sites to be distinguished from sites that were sampled and no RGSM were caught. The problem arises during statistical analyses because the naughty naughts (observations of zeros at dry sampling sites) are treated in the same manner as the zero catches at fished sites where no RGSM are caught.	Not given	1			ASIR excluded dry sites in their analyses. Dry sites are replaced.	2017 Population Monitoring Report, 2017 SOW with BOR
Hubert et al. 2016	28	5	Survey designs should strive to minimize false zeros resulting from: (1) an inappropriate sampling design (e.g., sampling in mesohabitats avoided by RGSM) and (2) ineffective survey methods (e.g., insufficient sampling effort to detect an organism when it is present).	Not given	1 and 2			Preliminary analysis from Population Monitoring WG shows that rare mesohabitats are sampled at a higher proportion than they exist in the environment (Valdez 2018)	Valdez 2018
Hubert et al. 2016	29	6	The proportions of various mesohabitat types sampled are likely to bias CPUE indices because the catchability coefficient probably differs among mesohabitat types and RGSM are likely to be selective for specific mesohabitat types. We recommend that better understanding of the influence of mesohabitat type on CPUE be developed and used to account for variability in CPUE indices. Further, we recommend that estimation of mean site-specific CPUE be improved by addressing the variable number of mesohabitats that are sampled at any given site and the amount of sampling in each mesohabitat type. We recommend estimation of mean site-specific CPUE from individual seine hauls (which are distinguishable in the database as of 2006); mean CPUE at each site is then computed from the individual CPUEs at each of the 18-20 mesohabitat units sampled per site.	Not given	1 and 2			ASIR has reported CPUE by mesohabitat type in their 2016 and 2017 reports. Some additional efforts towards this recommendation have been made by the DAT (Valdez 2018)	2017 Population Monitoring Report, Valdez 2018
Hubert et al. 2016	29	7	Environmental factors (e.g., turbidity, water temperature, substrate size, depth, current velocity, and discharge) during sampling are likely to bias CPUE indices because of their influence on catchability. We recommend that better understanding of the influence of measurable environmental factors on the catchability of each seine type be developed and used to account for variability in CPUE indices.	Not given	3			Sampling is not conducted above a certain CFS.	

Hubert et al. 2016	29	8	Factors influencing detection and catchability of RGSM in seines need to be determined and incorporated into the sampling design to permit more robust estimation of CPUE.	Not given	1				
Hubert et al. 2016	29	9	Measures of CPUE for RGSM from the MRG are currently identified as recovery standards for the species. We recommend modification of recovery standards to be explicit regarding the gear, sampling design, sampling techniques, data analysis, and life stage, as well as protocols used to compute the CPUE index.	Not given	0				
Hubert et al. 2016	29	10	We recommend depiction of the relationship of hydrological covariates and estimates of the mean annual CPUE for RGSM derived from the mixture model. Those relationships should use the October data from 1993 to 2014. Further, we recommend that such analyses be repeated for catch data collected in 2006 to the present, but using the individual seine-haul approach to estimate CPUE.	Not given	1			ASIR included some hydrological variables as covariates in their estimated desitiy models. More covariates of interest may be identified. The HBO assesment by Utah State University will look at hydrological covariates and CPUE. No analysis is being conducted at the individual seine-haul level.	
Hubert et al. 2016	29	11	We recommend that the assumptions of the mixture models be fully defined and that the results of analyses be interpreted with consideration of the assumptions and the effects of the potential violation of assumptions.	Not given	1			ASIR included a table in their 2017 Population Monitoring Report detailing assumptions, violation implications, violation risks, and mitigation precautions.	2017 Population Monitoring Report, 2017 SOW with BOR
Hubert et al. 2016	29	12	A greater number of sampling sites would improve the accuracy and precision of status assessments and improve estimates of RGSM CPUE and spatial distribution, especially at the reach scale. A greater number of sampling sites in each of the three reaches would facilitate status and trend estimates at the reach scale. To make statistically rigorous reach-scale CPUE estimates, 20-50 sites per reach are recommended. A design with substantially more sites and longer site lengths should be more effective at detecting RGSM when they are at low densities or demonstrating patchy distributions.	Not given	1			ASIR monitored 10 additional sites during the 2017 monitoring period and reported the results in their 2017 Population Monitoring report.	2017 Population Monitoring Report, 2017 SOW with BOR
Hubert et al. 2016	29	13	When river flows decline so that dry sampling sites occur among the 20 fixed sites sampled by the Monitoring Program, the ability to make inference regarding CPUE of RGSM over the MRG is impaired. The current 20-fixed-site sampling is not adequate when dry sampling sites occur. An ancillary randomized sampling design is recommended at such times to be able to make inferences about RGSM abundance and distribution throughout the entire MRG. Such a random sampling design would entail sampling at many more sites over the length of the MRG. An ancillary design of this type would enhance the feasibility of assessing the abundance and distribution of RGSM in the MRG during years of low flows and when the species is likely to occur in low abundance.	Not given	0			ASIR sampled replacement sites whenever the river was dry at a standard or additional site.	2017 Population Monitoring Report, 2017 SOW with BOR
Hubert et al. 2016	30	14	Consider using key drivers of mesohabitat variability, such as current velocity, substrate size, and water depth at specific locations where seines are deployed, to replace the mesohabitat factor in the mixture models.	Not given	2			May be considered in the next SOW	

Hubert et al. 2016	30	16	Examine the historical availability of mesohabitats in the MRG relative to discharge. If these two measures can be linked, then annual or monthly discharge may provide a good surrogate of mesohabitat availability.	Not given	2					
Hubert et al. 2016	30	17	Evaluate alternatives to the parametric mixture model, in particular, Bayesian hierarchical models, for estimating annual CPUEs.	Not given	2					
Hubert et al. 2016	30	18	Use classification and regression trees, boosted regression trees, or random forests to examine relationships between hydrologic variables and CPUE for identifying thresholds above or below which CPUE exhibits changes.	Not given	1.5					
Hubert et al. 2016	30	19	Implement directed studies using different sampling designs, such as multi-year, multi-site, before-after-control-impact (BACI) designs to enhance understanding of the response of the population to changes in river discharge, habitat rehabilitation projects, and availability of mesohabitats.	Not given	3					
Hubert et al. 2016	30	21	Conduct stock-recruitment studies to determine how the abundance of fall recruits relates to the abundance of spring spawners. Investigate the effects of spring and summer discharges on the stock recruitment relationship to enhance understanding of the dynamics of RGSM. Implement a spring sampling protocol at spawning sites to estimate the number of spring spawners, and compare with October results for several years; such studies may provide useful data on RGSM population dynamics and limiting factors.	Not given	3					
Hubert et al. 2016	30	22	Complete a study of age-specific fecundity and survival rates based on pre-breeding (fall) population estimates, spring spawners, and hatchery supplementation. Results from this study could be used to estimate population recovery and extirpation potentials as a function of altered flow regimes and stocking.	Not given	3				Not completed in MRGESCP, however Caldwell et al. report (2018) addresses age-specific fecundity, but not survival.	Caldwell et al. 2018
Hubert et al. 2016	30	23	Consider genetic fingerprinting and epigenetic studies, including bar-coding and gene-expression, of presumed wild and hatchery fish to help determine hatchery contributions to the spring spawners and the long-term risks to the wild population.	Not given	0					
Hubert et al. 2016	30	24	Expand the analyses in Dudley et al. (2015) to assess flow regime and habitat fragmentation effects on RGSM occurrence and abundance and suggest preliminary flow regimes for rehabilitating the wild RGSM population.	Not given	3					
Hubert et al. 2016	31	Observation Beyond the Scope 1	Attention to long-term climate-change issues and integration with climate-change planning efforts was not evident to the expert panelists (from the readings or from discussions at the December workshop) regarding how the Cooperative Program and Monitoring Program plan to address markedly lower flows and higher water temperatures.	Not given	Not given					

Hubert et al. 2016	31	Observation BTS 2	The MRG lacks minimum instream flow requirements to assure recovery. A major element of discussion by program scientists and interested parties during the workshop focused on low-flow periods and the potential for survival of RGSM during those periods when portions of the MRG have no observed surface flows or when there is no measurable discharge at gaging stations. It became evident to the external panelists that there are no specified minimum instream flow requirements or guidelines for the MRG. Minimum instream flow requirements or guidelines would not only enhance the potential for recovery of the RGSM in the MRG, but they would enable the current 20-site design of the Monitoring Program to be used to assess continuously status and trends of the RGSM stock in the MRG.	Not given	Not given				
Hubert et al. 2016	31	Observation BTS 3	The Monitoring Program assesses relative abundance of the RGSM in October; the young-of-year fish encountered at this time are likely to include the progeny of hatchery fish that were stocked the previous year (in November), survived the winter, and successfully reproduced. As such, the Monitoring Program is measuring the ability of hatchery stocking to contribute to or maintain a population in the MRG. Understanding of the dynamics of the RGSM population and the effects of changes in water resources in the MRG is hindered by confounding of environmental and hatchery-fish effects. There is a need for Monitoring Program scientists to effectively disentangle the source of new recruits (Creel et al. 2015), in particular the relative contribution of hatchery-origin fish and naturally spawned wild fish. One suggestion is to apply individual-based models (IBMs) to simulate changes in the system (e.g., cessation of stocking, decreased discharge rates) and assess those effects on RGSM populations (see e.g., Rose et al. 2013a and b). IBMs are used to describe population outcomes by tracking the fate of the individual fish that compose the population. As such, these models allow individual fish to exhibit unique combinations of growth, survival, fecundity, and movement probabilities. Although this is a powerful approach for the study of animal populations, IBMs require large amounts of data. Thus, the feasibility of this approach will depend on the depth of knowledge of basic biological processes for RGSM in the 1186 MRG.	Not given	Not given				

Hubert et al. 2016	31	Observation BTS 4	In recent years, low RGSM abundance has led to salvaging fish from residual pools and the introduction of hatchery reared fish to supplement the RGSM population. This creates a dilemma of providing fish to preclude RGSM extinction versus creating a domesticated hatchery-dominated population ill equipped to survive the rigors of a highly stressed environment. Therefore, additional genetic fingerprinting and epigenetic studies of presumed wild, hatchery, and hatchery-originated progeny are needed to determine hatchery contributions to the spring spawners and the risks thereof to the wild population (Quinones et al. 2014; Trushenski et al. 2015; Carmichael et al. 2015)...The question of greatest concern here is the degree to which the population has become, or is becoming, a largely hatchery-derived population with reduced survivability in the face of climate change and other physical and chemical habitat alterations. This becomes of greatest concern when wild populations are naturally and anthropogenically constricted in numbers relative to the numbers of hatchery-origin fish added to the population. Because of such natural and anthropogenic pressures, the highly variable RGSM population likely will continue to be reduced and the wild population may be extirpated (Lawson 1993; Cowley 2006). Continuation of current hatchery augmentation practices should include a rigorous risk/benefit analysis.	Not given	Not given			0	
Hubert et al. 2016	32	Observation BTS 5	Although not explicitly discussed during the December workshop, the current recovery plan and criteria for the RGSM (USFWS 2010) are based on the 20-fixed-site sampling protocol. Recovery criteria for the MRG include presence of unmarked and age-0 RGSM at 75% of all sites per reach in October; an October CPUE of >5 RGSM/100 m2 in all sites in a reach for five consecutive years; and age-0 RGSM in 75% of all sites in a reach for five consecutive years. To the degree that insufficient October flows limit sampling of all 20 sites, those recovery criteria cannot be met. In addition, the recovery plan implicitly assumes that genetic exchange is generally in a downstream direction, that the wild RGSM genetic composition has been preserved, and that unmarked fish have a wild genotype. However, those assumptions may be negated by ongoing hatchery practices as discussed above in Observation 4.	Not given	Not given			ASIR sampled at replacement sites when a fixed or additional site was found to be dry. They also added 10 additional sites in 2017.	2017 Population Monitoring Report, 2017 SOW with BOR

Hubert et al. 2016	32	Observation BTS 6	The analyses in Dudley et al. (2015) could lead to quantitative instream flow and habitat studies and be used to assess flow regime and habitat fragmentation effects on RGSM occurrence and abundance and then used to set preliminary system-wide instream flow criteria for rehabilitating RGSM. This is because current rehabilitation actions such as salvage, stocking of hatchery fish, and local flow and physical habitat manipulations have only local or temporary effects compared with the system-wide effects of major diversion dams and basin-scale land use (e.g., Wang et al. 2003; Hughes et al. 2005, 2014). Normalizing flow regimes, improving fish passage, and extensively lowering floodplains would help rehabilitate a species such as the RGSM (Williams et al. 1999; Tockner et al. 2000; Dudley et al. 2015; Novak et al. 2015); admittedly, such rehabilitation measures may be costly. Although portions of the MRG have experienced periods of natural drying and flooding historically, anthropogenic increases in the frequency or extent of drying and anthropogenic decreases in the frequency and extent of flooding, together with passage barriers, likely reduce the potential of wild RGSM to persist and flourish in the MRG (Hughes et al. 2005; Novak et al. 2015).	Not given	Not given				
Hubert et al. 2016	33	Observation BTS 7	During the workshop, the panelists noted that a number of organizations and agencies were engaged in research on RGSM in the MRG (i.e., US Fish & Wildlife Service, Bureau of Reclamation, and Army Corps of Engineers). However, the expert panelists did not identify whether formal procedures for sharing outcomes and results from these studies are in place, for example, via annual multi-day research review and discussion meetings with all Cooperative Program and Monitoring Program partners. In addition, models to describe the hydrodynamics of the MRG have been developed, but fish population studies do not appear to make use of these models. The water resource problems in the MRG are complex and water management actions affecting discharge and flow in the river affect the population of RGSM. An annual research review or similar activity may help to strengthen information exchange and advance scientific understanding of the issues in the MRG.	Not given	Not given			Planning 2019 MRG Science Symposium	

Hubert et al. 2016	33	Observation BTS 8	An adaptive management program may help to improve understanding of the relationship between management actions in the MRG and the status of the RGSM population. We understand that such an approach will soon be implemented for the MRG and encourage the Collaborative Program to pursue a rigorous adaptive management program. Adaptive management is typically viewed as a partnership between management agencies and agencies engaged in research to address critical uncertainties in the system. Partnerships are key because new knowledge about the system will be obtained only when research and management work hand-in-hand. In adaptive management, (1) the science problems must be defined in a clear manner that permits design of targeted investigations; (2) conceptual and simulation models are then used to investigate responses of the system to potential management interventions; (3) direct, purposeful manipulations are implemented and the response of the system measured in a statistically reliable manner; and (4) analyses and synthesis of outcomes are completed in a timely manner to support robust decision-making. Adaptive management in the MRG would benefit from a conceptual model of the system that integrates water use, hydrodynamics, and fish population responses. It is unclear if such a model exists, but it is imperative to develop such models to ensure that management manipulations will provide sufficient contrast and ensure a measurable result.	Not given	Not given			Planning 2019 MRG Science Symposium and working towards an Adaptiveme Management Framework for the program.	
Hubert et al. 2016	33	Observation BTS 9	In addition to adaptive management, Collaborative Program partners and collaborators may wish to consider other tools such as scenario planning (Baker et al. 2004; Hulse et al. 2004; Allen and Gunderson 2011; Rowland et al. 2014) and resilience building (NYC 2013; Norfolk 2014). Scenario planning may be an effective management approach when uncertainty about the system is high and factors that affect the system are not readily controlled (e.g., amount of snow pack available for replenishment of rivers). In this approach, alternative futures are explored with the goal of identifying improvements to current management actions. This may be a good strategy to pursue now, perhaps together with adaptive management. As uncertainty about the system declines (through learning derived from targeted research studies and adaptive management), we suggest implementing a resilience building approach. The approach is effective when driving factors remain uncontrollable and system uncertainty is low. Many coastal cities have adopted this approach in the face of rising sea levels (e.g., New York City [NYC 2013] and Norfolk, VA [Norfolk 2014]).	Not given	Not given				

Hubert et al. 2016	33	Observation BTS 10	The research done on the RGSM warrants publication in high-level peer reviewed journals. The Expert Panel was provided 14 documents to help it prepare for the December workshop. Of those 14, only 2 were published in, or submitted to, a peer-reviewed journal by a member of the Program; however, the results and interpretations included in the annual reports should be published in journals. Similarly, the Expert Panelists were shown agency reports at the Workshop that were not included in the preselected workshop reading materials that likely had received thorough agency review, but apparently had not yet been submitted for journal publication. In the scientific world, peer-reviewed journal publication is the standard by which research is judged. Publishing in such journals would add increased scientific credibility to the Collaborative Program, and funding the time needed to prepare and revise journal manuscripts should be included in the research grants of the Monitoring Program.	Not given	Not given			SOWs developed through the Program now accommodate the cost of peer-reviewed publication.	
Noon et al. 2017	17	A1	Clarify the relationship between the annual catch-per-unit-effort and true population size by estimating catchability.	1	1		Same as Caplan et al. 2018 - RGSM 1		
Noon et al. 2017	18	A2	Determine the key, age-specific, life history sensitivities of the RGSM (that is, use eigenanalysis methods to determine which vital rates [survival and/or reproduction] most affect rathes of population change.	1	3		Same as Caplan et al. 2018 - RGSM 2		
Noon et al. 2017	18	A3	Estimate age-specific survival rates	1	3		Same as Caplan et al. 2018 - RGSM 3		
Noon et al. 2017	19	A4	Estimate age-specific fecundities of wild fish.	1	3		Same as Caplan et al. 2018 - RGSM 4	Age-specific fecundities were determined for captive fish. Published in the North American Journal of Aquaculture in 2019.	Caldwell et al. 2019
Noon et al. 2017	19	A5	Using statistical modeling, estimate the relationships between RGSM demographic rates and A.) hydrological factors (flow magnitude and duration, summer drying of the channel); and B.) abiotic environmental factors (temperature, turbidity, salinity); and C.) biotic factors (predation, completion, prey availability).	1	3		Same as Caplan et al. 2018 - RGSM 5		
Noon et al. 2017	20	A6	Evaluate the existence and strength of any density-dependent factors that may be limiting population growth.	2	Not given				
Noon et al. 2017	20	A7	Model the potential effects of hatchery augmentation on population dynamics and the significance of hatchery fish to achieving recovery objectives.	Not given	Not given				
Noon et al. 2017	20	A8	Determine if the collection and translocation of salvage fish during summery drying periods contributes signficantly to population dynamics.	Not given	Not given			The USFWS is in the very preliminary stages of assessing survival post-fish salvage. A portion of rescued fish are being brought back to the USFWS facilities for evaluation.	2018
Noon et al. 2017	21	B1	Development and deplyment of "vertically-intergrating" Moore egg collectors	1	Not given				

Noon et al. 2017	21	B2	Improved assessments of relations between possible environmental cues that trigger spawning activity.	1	Not given			Temperature degree days and photoperiod SOW currently addresses a few potential environmental cues.	SOW developed in 2018
Noon et al. 2017	21	B3	Establish size-specific fecundities of natural-spawning RGSM.	2	Not given				
Noon et al. 2017	22	C	Clarify the detail of annular mark formation on otoliths and firmly establish the longevity of RGSM	2	Not given			SWCA currently addressing this for larval fish only (to get hatch date).	2018
Noon et al. 2017	22	D1	Estimate the spatial extent and hyrdaulic quality used by RGSM for key life-stages (spawining, larval rearing, juvenile and adult survival). Estimate how these habitats are distributed in the river channel and floodplain in each MRG reach under a range of discharges and seasonal flow regimes.	Not given	Not given				
Noon et al. 2017	23	D2	Establish the proximate trigger(s) for spawning by evaluating the effects of flow velocity, temperature, rate of increase in flow velocity, or some combination of these factors.	Not given	Not given			Temperature degree days and photoperiod SOW currently addresses a few potential environmental cues.	SOW developed in 2018
Noon et al. 2017	23	D3	Determine the roles and relative contributions to fish production (age 0 recruitment and survival of all age-classes) of channel and floodplain habitat in a reach of channel and floodplain typical of the MRG.	Not given	Not given				
Noon et al. 2017	24	D4	What is the management potential for fish production (recruitment and survival of age 0 fish) in each reach of the MRG if the annual peak flow, and thus the nature and range of available habitats, is permanently limited below historic levels of availability.	Not given	3				
Noon et al. 2017	24	E1	Establish the age composition of the RGSM population, including A.) application of distribution seperation methods to estimate age composition, and B.) gear selection study.	1	Not given			Horowitz et al. 2018 addressed age composition, and some additional work done by Valdez (2018)	
Noon et al. 2017	25	E2	Determine how the vertical and horizontal distribution of RGSM eggs in the MRG mainstream channel varies as a function of flow and location?	1	Not given			M.Porter (?)	
Noon et al. 2017	25	E3	Calculate revised CPUE values as mesohabitat-specific levels and do not combine across mesohabitat types. The meso-habitat specific CPUE calculated for the most abundadnt high density mesohabitat type should be used for assessment of trend in abundance of the RGSM population at the October sampling date.	2	2			ASIR has reported CPUE by mesohabitat type in their 2016 and 2017 reports. Some additional efforts towards this recommendation have been made by the DAT.	2017 Population Monitoring Report, 2017 SOW with BOR
Caplan et al. 2018	23	NMMJM1	Where are the NMMJM populations located?	1					
Caplan et al. 2018	25	NMMJM2	What is the genetic variation within and between NMMJM populations?	1					
Caplan et al. 2018	27	NMMJM3	How do non-invasive survey methods compare to trapping?	2					
Caplan et al. 2018	28	NMMJM4	What are the attributes for foraging, day nesting, maternal nesting, and hibernation habitat in the MRG?	2					
Caplan et al. 2018	30	NMMJM5	What are the population dynamics for the NMMJM?	2					

Caplan et al. 2018	35	SWFL1	What site selection and prioritization procedures contribute to the successful restoration of SWFL breeding habitats along the MRG?	1				In contract with USACE, Tetra Tech is identifying sites suitable for SWFL restoration in the MRG based on a large suite of factors.	Currently under contract in 2019
Caplan et al. 2018	41	SWFL2	What are the impacts of the tamarisk beetle (Diorhabda) on SWFLs and suitable SWFL breeding habitats in the MRG?	2					
Caplan et al. 2018	41	SWFL3	Which unoccupied and occupied suitable SWFL breeding habitats in the MRG are most threatened by Diorhabda in the near- and long-term?	2					
Caplan et al. 2018	46	SWFL4	What are the sizes, distributions, and trends of SWFL breeding populations along the Angustora Reach?	2					
Caplan et al. 2018	48	SWFL5	What is the connectivity among SWFL populations in the MRG?	3					
Caplan et al. 2018	56	YBCU1	Which abiotic and biotic variables predict suitable YBCU breeding habitats in the MRG across multiple spatial and temporal scales?	1					
Caplan et al. 2018	59	YBCU2	What are YBCU breeding population sizes, distributions, and trends in the MRG?	2				SOW written to assess the genetics of the YBCU to help better determine the distribution of the endangered sub-species.	Will be contracted as a grant in 2019 or 2020
Caplan et al. 2018	61	YBCU3	How similar are the YBCU and the SWFL in their breeding habitat requirements in the MRG?	2					
Caplan et al. 2018	64	YBCU4	What are the spatial behavior patterns of YBCUs that breed in the MRG within and among years?	2					
Caplan et al. 2018	74	RGSM1	What are the key age-specific fecundity and survival rates (e.g., life-history sensitivities) that have the greatest impacts on RGSM population growth?	1			Same as Noon et al. 2017 A1		
Caplan et al. 2018	75	RGSM2	What are the age-specific survival rates, and their variances, of RGSM?	1			Same as Noon et al. 2017 A2		
Caplan et al. 2018	78	RGSM3	What are the age-specific fecundities, and their variances, of RGSM?	1			Same as Noon et al. 2017 A3		
Caplan et al. 2018	80	RGSM4	Can the relationship between the annual CPUE index and true population size be better characterized?	1			Same as Noon et al. 2017 A4		
Caplan et al. 2018	83	RGSM5	What is the relationship between RGSM demographic rates and : A) hydrologic factors; B) abiotic environmental factors; and C) biotic factors in the MRG?	1			Same as Noon et al. 2017 A5		