Science and Habitat Restoration Work Group Meeting

October 17, 2019

Meeting Materials:

Agenda

Minutes

USACE AM Workshop - Team CEMs [read-ahead]

Bibliography of SWFL Literature [read-ahead, draft]

Bibliography of YBCU Literature [read-ahead, draft]

Caplan RGSM Conceptual Models [read-ahead]

MRGESCP: Adaptive Management Plan Version 1 Conceptual Model for the RGSM [read-ahead]

MRGESCP: Adaptive Management Plan Version 1 Conceptual Model for the SWFL [read-ahead]

RGSM Conceptual Models [presentation]

SWFL Basic CEM for the Lower Colorado River [read-ahead]

Technical Report Appendix F: SWFL Breeding Habitat Prediction Modeling [read-ahead]

SWFL Breeding Habitat Conceptual Model [read-ahead]

Western YBCU Basic CEM for the Lower Colorado River [read-ahead]

Middle Rio Grande Endangered Species Collaborative Program

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Science and Habitat Restoration Work Group (ScW/HR)

October 17, 2019
9:00 AM – 12:00 PM

U.S. Fish and Wildlife Service
2105 Osuna Rd NE

Meeting Agenda

9:00 – 9:10	**Welcome, Introductions, and Agenda Review** ➢ **Decision**: Approval of October 17, 2019 meeting agenda	*Program Support Team*
9:10 – 9:20	**Review of September 4, 2019 ScW/HR Meeting** • Review Action Items ➢ **Decision**: Approval of September 4, 2019 meeting minutes	*Program Support Team*
9:20 – 9:45	**Conceptual Ecological Model Discussion** • Discuss the different formats used in the models distributed as read-aheads	*Group Discussion*
9:45-10:45	**Conceptual Ecological Model Development** • Break into two, small groups to review existing models and develop models for the following species: o RGSM o SWFL and YBCU	*Group Discussion*
10:45-10:55	**Break**	*Group Discussion*
10:55 – 11:55	**Conceptual Ecological Model Development Continued**	*Group Discussion*
11:55-12:00	**Additional Items and Next Meeting Date** ➢ **Action Item**: Determine agenda items for the next ScW/HR meeting ➢ **Action Item**: Set date(s) for future meeting(s)	*Group Discussion*
12:00	**Adjourn**	

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Science and Habitat Restoration Work Group (ScW/HR)
Meeting Minutes

October 17, 2019
Location: U.S. Fish and Wildlife Service
2105 Osuna Rd NE

Decisions:

- Approval of the October 17, 2019 ScW/HR meeting agenda
- Approval of the September 4, 2019 ScW/HR meeting minutes

Actions:

WHO	ACTION ITEM	BY WHEN
Program Support Team (PST)	Distribute presentation slides to ScW/HR	ASAP
PST	Develop draft conceptual models based on small group discussions	November 14

Next Meeting: November 21, 2019, 9am – 12pm

Meeting Notes

Welcome and Introductions

- ➢ **Decision:** The October 17, 2019 meeting agenda was approved

Review of the September 4, 2019 meeting

- ➢ **Decision:** The September 4, 2019 meeting minutes were approved

Presentation: Conceptual Ecological Models for the MRG by Ashley Tanner (PST)
Following the presentations and recommendation from the U.S. Army Corp of Engineers Engineering Research and Development Center (USACE ERDC), Ashley T. presented on some considerations for the group to keep in mind during the development of conceptual ecological models (CEM).

The following comments were made regarding the MRG Systems Model displayed in the presentation:

- The model may represent both the spatial distribution of vegetation (a cross-section of the river) and vegetation changes through time at one particular location (succession).
- The temporal line may be too far into the "river" portion of the picture.

- There was some discussion on whether the systems model was too idealistic. More specifically, the depiction of succession in the center of the model may represent succession that we don't really see today with the influence of invasive species and other issues.
- It was suggested that the group keep in mind what management options exist within the system. The group could spend a lot of time identifying uncertainties, but they may not be important to address if they're not related to something that can be modified. It would be helpful to know where management decisions can be made. It was suggested that the adaptive management piece may need to come first.
    - In response, it was cautioned that the group could limit itself by saying something is "not possible." It was stated that a lot of management changes have taken place over the past 15 years. While management should certainly be kept in mind, it might not be best to constrain the group to only what is "possible" under current management conditions.

The following comments were made regarding other aspects of the presentation:

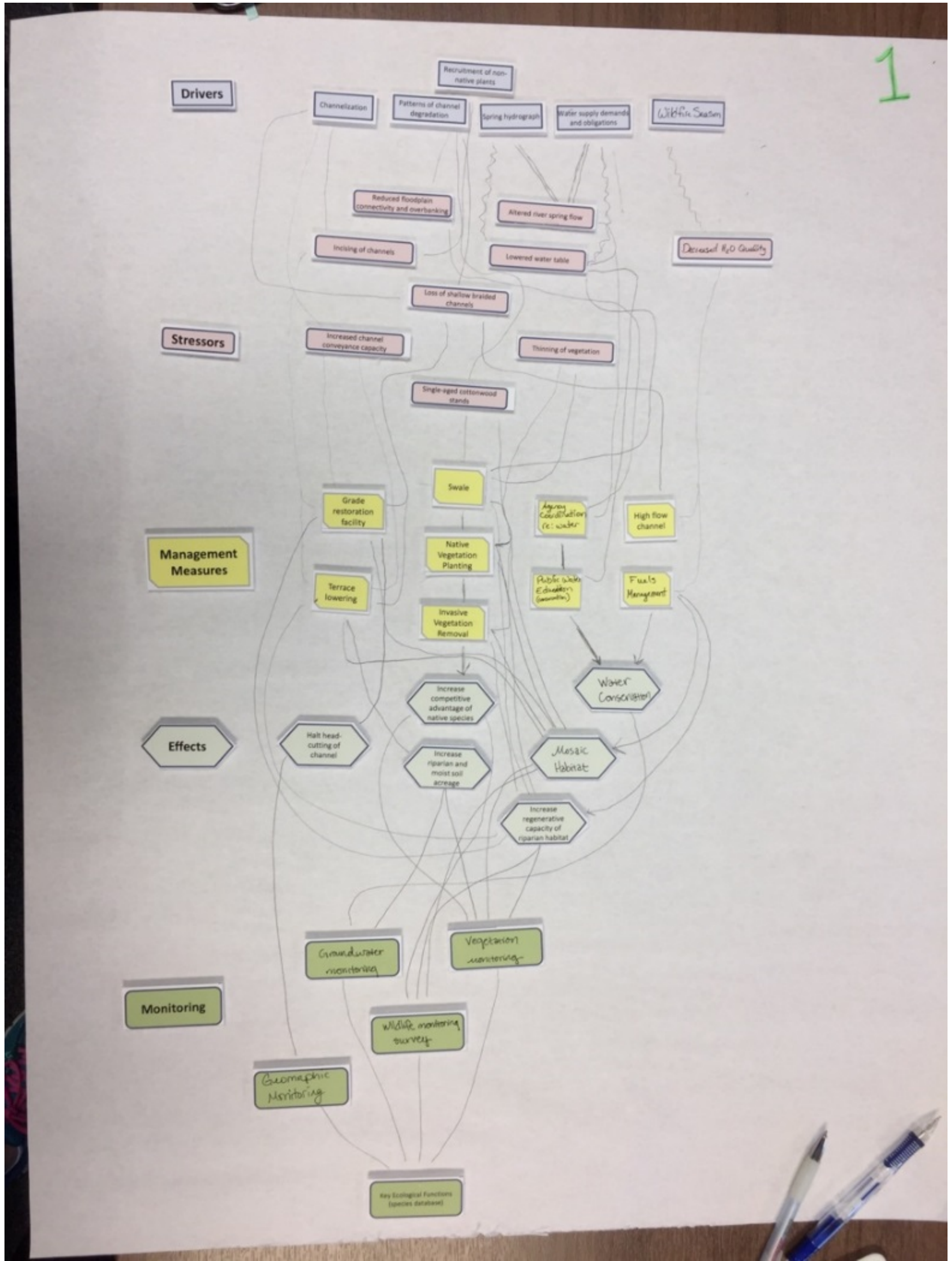
- It was suggested that the critical factors analyses done by the U.S. Fish and Wildlife Service (USFWS) for each listed species may be easily incorporated into the species-specific conceptual models.
- The group discussed 3 levels of models: a systems model, species-specific models, and models derived from the first two that are more specific to a relationship that warrants further examination.

Conceptual Ecological Model Development

The work group proceeded to divide into two groups: one developing a model for the Rio Grande silvery minnow (RGSM) and one for the southwest willow flycatcher (SWFL) and yellow-billed cuckoo (YBCU). Notes were not taken during this workshop portion of the meeting.

Meeting Participants

Participant	Organization
Ashley Tanner	PST
Aubrey Harris	USACE
Cathy Nishida	Pueblo of Santa Ana
Chuck Hayes	NMDGF
Clint Smith	USFWS
Dana Price	USACE
Danielle Galloway	USACE
Debbie Lee	PST
Grace Haggerty	NMISC
Meghan Conway	NMDGF
Mike Marcus	APA
Mo Hobbs	ABCWUA
Nathan Schroeder	Pueblo of Santa Ana
Rich Valdez	SWCA
Steven Ryan	USACE
Terry McDill	NMISC
Trevor Birt	NMISC
Vicky Ryan	USFWS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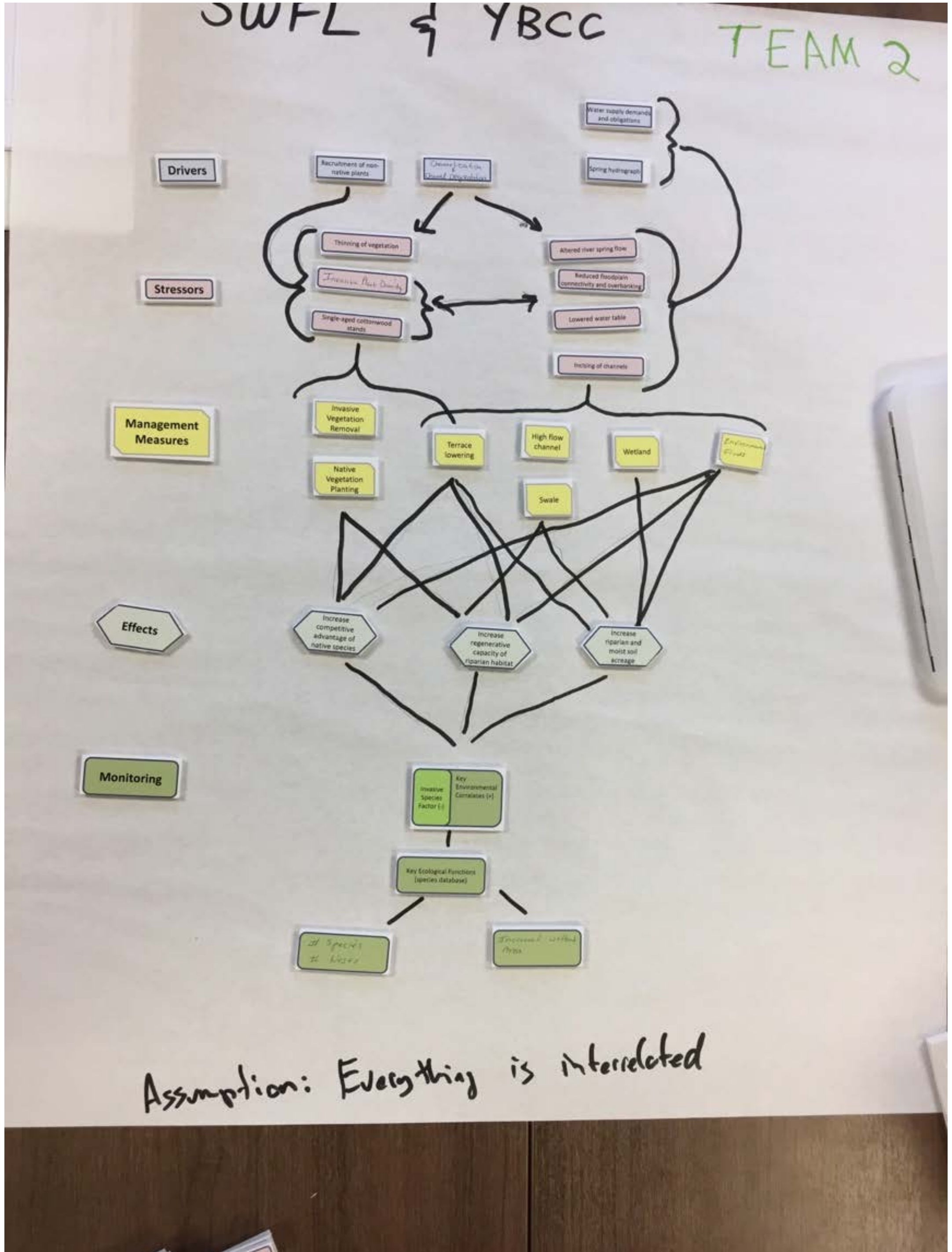
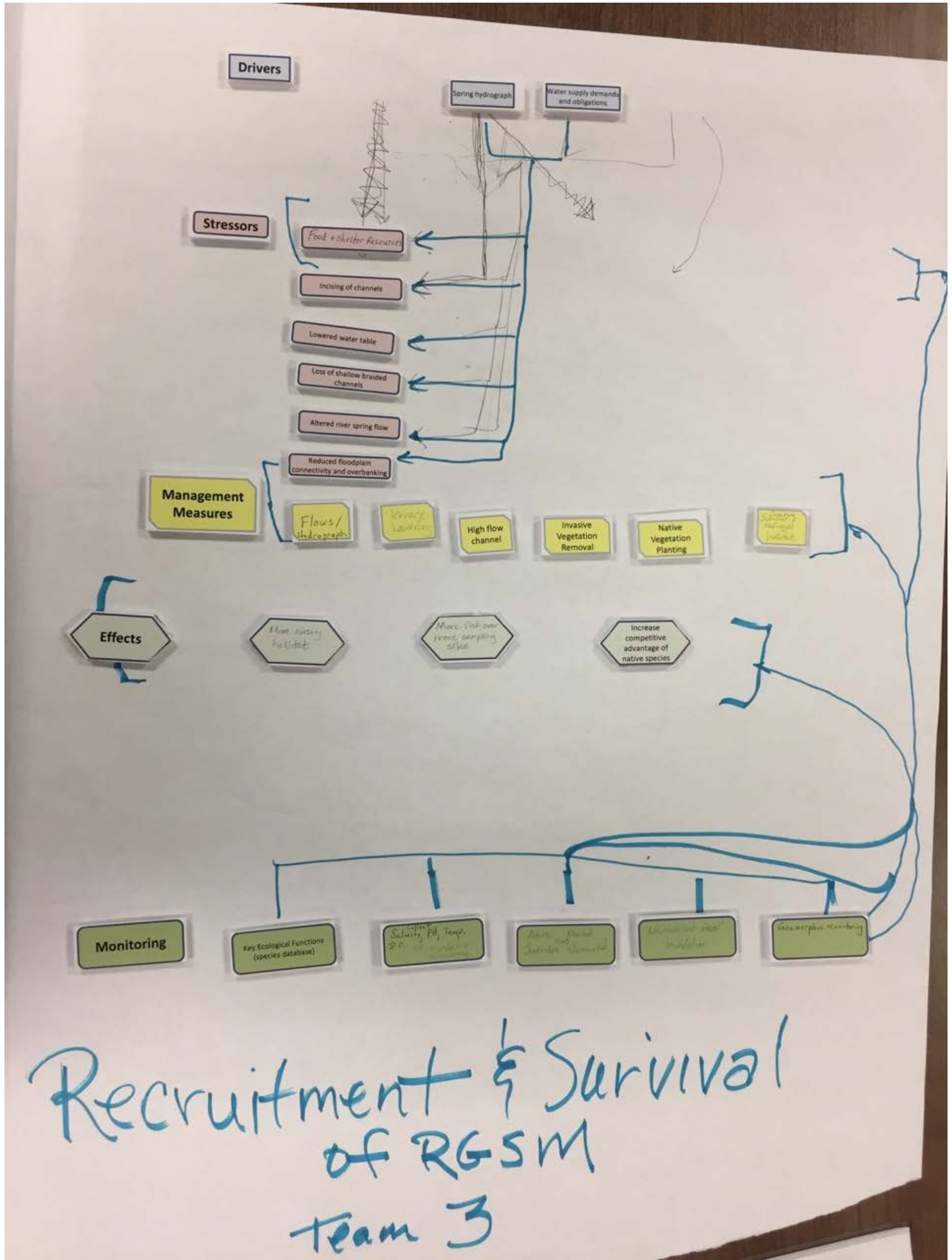
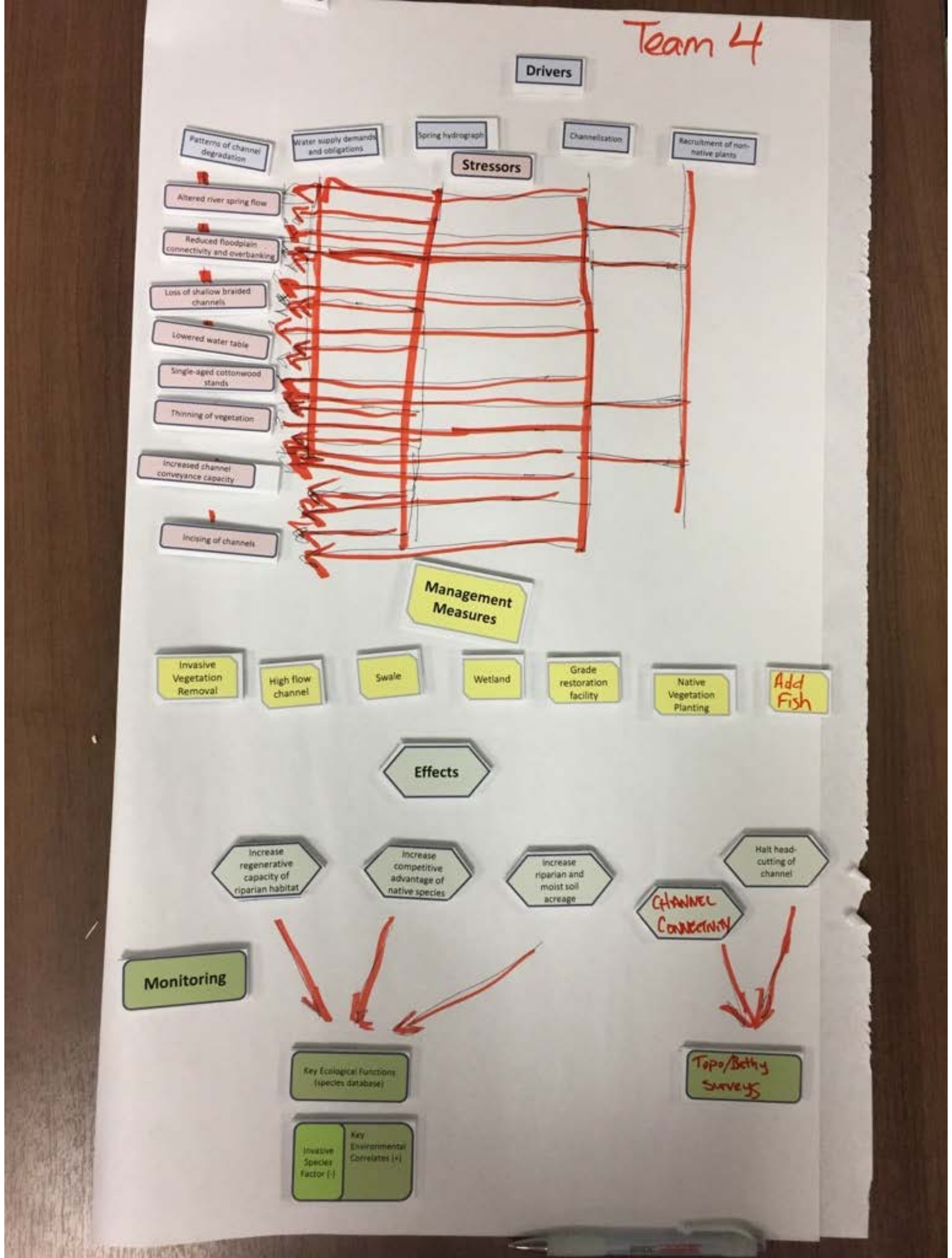
Drivers
Recruitment of non-native plants
Channelization
Patterns of channel degradation
Spring hydrograph
Water supply demands and obligations
Wildfire Season
Reduced floodplain connectivity and overbanking
Altered river spring flow
Incising of channels
Lowered water table
Decreased H_2O Quality
Loss of shallow braided channels
Stressors
Increased channel conveyance capacity
Thinning of vegetation
Single-aged cottonwood stands
Swale
Grade restoration facility
Agency Coordination re: water
High flow channel
Management Measures
Native Vegetation Planting
Terrace lowering
Public Wide Education
Fuels Management
Invasive Vegetation Removal
Water Conservation
Increase competitive advantage of native species
Effects
Halt head-cutting of channel
Increase riparian and moist soil acreage
Mosaic Habitat
Increase regenerative capacity of riparian habitat
Groundwater monitoring
Vegetation monitoring
Monitoring
Wildlife monitoring survey
Geomorphic Monitoring
Key Ecological Functions (species database)

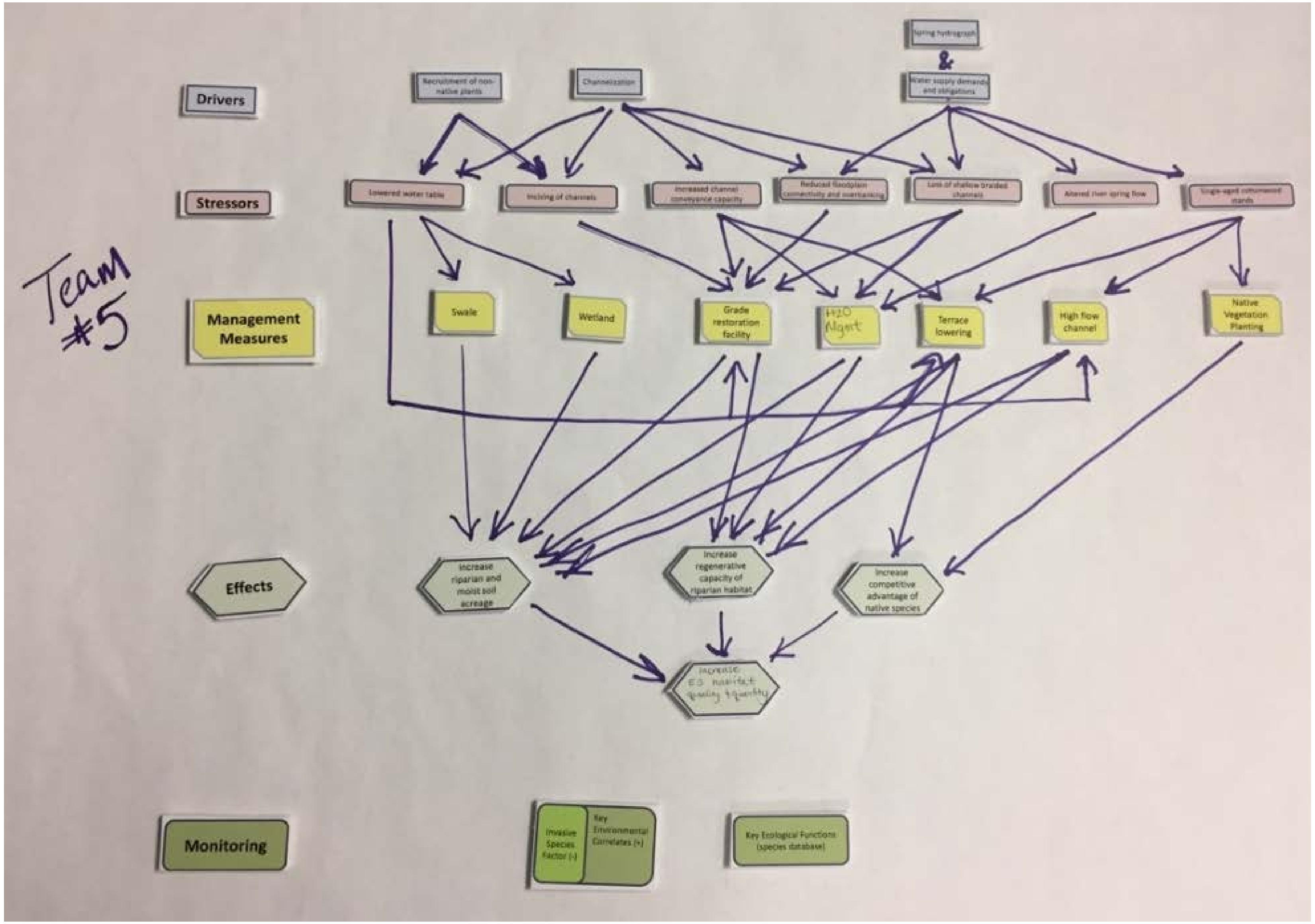

SWFL & YBCC
TEAM 2
Drivers
Recruitment of non-native plants
Water supply demands and obligations
Spring hydrograph
Stressors
Thinning of vegetation
Single-aged cottonwood stands
Altered river spring flow
Reduced floodplain connectivity and overbanking
Lowered water table
Incising of channels
Management Measures
Invasive Vegetation Removal
Native Vegetation Planting
Terrace lowering
High flow channel
Swale
Wetland
Effects
Increase competitive advantage of native species
Increase regenerative capacity of riparian habitat
Increase riparian and moist soil acreage
Monitoring
Invasive Species Factor (-)
Key Environmental Correlates (+)
Key Ecological Functions (species database)
Assumption: Everything is interrelated



Drivers
Spring hydrograph
Water supply demands and obligations
Stressors
Food + shelter Resources
Incising of channels
Lowered water table
Loss of shallow braided channels
Altered river spring flow
Reduced floodplain connectivity and overbanking
Management Measures
Flows/ hydrograph
High flow channel
Invasive Vegetation Removal
Native Vegetation Planting
Effects
Increase competitive advantage of native species
Monitoring
Key Ecological Functions (species database)
Geomorphic Monitoring
Recruitment & Survival of RGSM
team 3



Team 4
Drivers
Patterns of channel degradation
Water supply demands and obligations
Spring hydrograph
Channelization
Recruitment of non-native plants
Stressors
Altered river spring flow
Reduced floodplain connectivity and overbanking
Loss of shallow braided channels
Lowered water table
Single-aged cottonwood stands
Thinning of vegetation
Increased channel conveyance capacity
Incising of channels
Management Measures
Invasive Vegetation Removal
High flow channel
Swale
Wetland
Grade restoration facility
Native Vegetation Planting
Add Fish
Effects
Increase regenerative capacity of riparian habitat
Increase competitive advantage of native species
Increase riparian and moist soil acreage
Halt head-cutting of channel
Channel Connectivity
Monitoring
Key Ecological Functions (species database)
Topo/Bathy Surveys
Invasive Species Factor (-)
Key Environmental Correlates (+)



Team #5
Drivers
Recruitment of non-native plants
Channelization
Spring hydrograph
&
Water supply demands and obligations
Stressors
Lowered water table
Incising of channels
Increased channel conveyance capacity
Reduced floodplain connectivity and overbanking
Loss of shallow braided channels
Altered river spring flow
Single-aged cottonwood stands
Management Measures
Swale
Wetland
Grade restoration facility
H2O Mgmt
Terrace lowering
High flow channel
Native Vegetation Planting
Effects
Increase riparian and moist soil acreage
Increase regenerative capacity of riparian habitat
Increase competitive advantage of native species
Increase ES habitat quality + quantity
Monitoring
Invasive Species Factor (-)
Key Environmental Correlates (+)
Key Ecological Functions (species database)

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Bibliography of Southwestern Willow Flycatcher Literature

Peer-Reviewed Literature Cited

Bangert, R., S. M. Ferrier, L. Evans, K. Kennedy, K. C. Grady, E. Hersch-Green, G. J. Allan, and T. G. Whitham. 2013. The Proportion of Three Foundation Plant Species and Their Genotypes Influence an Arthropod Community: Restoration Implications for the Endangered Southwestern Willow Flycatcher: Plant Proportions and Genotypes in Restoration. *Restoration Ecology* 21:447–456.

Bateman, H. L., T. L. Dudley, D. W. Bean, S. M. Ostoja, K. R. Hultine, and M. J. Kuehn. 2010. A River System to Watch: Documenting the Effects of Saltcedar (*Tamarix* spp.) Biocontrol in the Virgin River Valley. *Ecological Restoration* 28:405–410.

Boucher, P. F., S. H. Stoleson, R. S. Shook, R. D. Pope, and J. Monzingo. 2003. Riparian Restoration on the Gila River, New Mexico, Creates Breeding Habitat for Southwestern Willow Flycatcher. *Studies in Avian Biology* 26:135–142.

Brodhead, K. M., S. H. Stoleson, and D. M. Finch. 2007. Southwestern Willow Flycatchers (*Empidonax traillii extimus*) in a Grazed Landscape: Factors Influencing Brood Parasitism. *The Auk* 124:1213–1228.

Brown, B. T., and M. W. Trosset. 1989. Nesting-Habitat Relationships of Riparian Birds along the Colorado River in Grand Canyon, Arizona. *The Southwestern Naturalist* 34:260.

Busch, J. D., M. P. Miller, E. H. Paxton, M. K. Sogge, and P. Keim. 2000. Genetic Variation in the Endangered Southwestern Willow Flycatcher. *The Auk* 117:586–595.

Campbell, C. L. 2009. Southwestern Willow Flycatcher (*Empidonax traillii extimus*) Population Trends at the Gila Lower Box, New Mexico. *New Mexico Ornithological Society Bulletin* 37:25–40.

Dudley, T. L., and D. W. Bean. 2012. Tamarisk biocontrol, endangered species risk and resolution of conflict through riparian restoration. *BioControl* 57:331–347.

Dudley, T. L., and C. J. Deloach. 2004. Saltcedar (*Tamarix* spp.), Endangered Species, and Biological Weed Control—Can They Mix? [1]. *Weed Technology* 18:1542–1551.

Durst, S. L., T. C. Theimer, E. H. Paxton, and M. K. Sogge. 2008. Temporal variation in the arthropod community of desert riparian habitats with varying amounts of saltcedar (*Tamarix* ramosissima). *Journal of Arid Environments* 72:1644–1653.

Durst, S. L., T. C. Theimer, E. H. Paxton, and M. K. Sogge. 2008. Age, Habitat, and Yearly Variation in the Diet of a Generalist Insectivore, the Southwestern Willow Flycatcher. *The Condor* 110:514–525.

Ellis, L. A., S. D. Stump, and D. M. Weddle. 2009. Southwestern Willow Flycatcher Population and Habitat Response to Reservoir Inundation. *Journal of Wildlife Management* 73:946–954.

Fernández-Juricic, E., A. J. del Nevo, and R. Poston. 2009. Identification of Individual and Population-level Variation in Vocalizations of the Endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*). *The Auk* 126:89–99.

Friggens, M. M., and D. M. Finch. 2015. Implications of Climate Change for Bird Conservation in the Southwestern US under Three Alternative Futures. *PloS One* 10:e0144089.

García-Hernández, J., O. Hinojosa-Huerta, V. Gerhart, Y. Carrillo-Guerrero, and E. P. Glenn. 2001. Willow flycatcher (*Empidonax traillii*) surveys in the Colorado River delta: implications for management. *Journal of Arid Environments* 49:161–169.

Graf, W. L., J. Stromberg, and B. Valentine. 2002. Rivers, dams, and willow flycatchers: a summary of their science and policy connections. *Geomorphology* 47:169–188.

Hatten, J. R., and C. E. Paradzick. 2003. A Multiscaled Model of Southwestern Willow Flycatcher Breeding Habitat. *The Journal of Wildlife Management* 67:774–788.

Hatten, J. R., E. H. Paxton, and M. K. Sogge. 2010. Modeling the dynamic habitat and breeding population of Southwestern Willow Flycatcher. *Ecological Modelling* 221:1674–1686.

Johnson, K., P. Mehlhop, C. Black, and K. Score. 1999. Reproductive failure of endangered southwestern willow flycatchers on the Rio Grande, New Mexico. *The Southwestern Naturalist* 44:226–231.

Johnson, R. R., E. E. Johnson, and S. W. Carothers. 2018. Chapter 11. Terrestrial Vertebrates of Mesquite Bosques in Southwestern North America. Page 24 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Kelly, J. F., M. J. Johnson, S. Langridge, and M. Whitfield. 2008. Efficacy of Stable Isotope Ratios in Assigning Endangered Migrants to Breeding and Wintering Sites. *Ecological Applications* 18:568–576.

Koronkiewicz, T. J., E. H. Paxton, and M. K. Sogge. 2005. A technique to produce aluminum color bands for avian research. *Journal of Field Ornithology* 76:94–97.

Kus, B. E., P. P. Beck, and J. M. Wells. 2003. Southwestern Willow Flycatcher Populations in California: Distribution, Abundance, and Potential for Conservation. *Studies in Avian Biology* 26:12–21.

Kus, B. E., S. L. Howell, and D. A. Wood. 2017. Female-biased sex ratio, polygyny, and persistence in the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*). *The Condor* 119:17–25.

Kus, B. E., and M. J. Whitfield. 2005. Parasitism, Productivity, and Population Growth: Response of Least Bell's Vireos (*Vireo bellii pusillus*) and Southwestern Willow Flycatchers (*Empidonax traillii extimus*) to Cowbird (*Molothrus* spp.) Control. *Ornithological Monographs* 16–27.

Mahoney, S. M., A. N. B. Smith, P. J. Motyka, E. J. Lundgren, R. R. Winton, B. Stevens, and M. J. Johnson. 2019. Russian olive habitat along an arid river supports fewer bird species, functional groups and a different species composition relative to mixed vegetation habitats. *Journal of Arid Environments* S0140196319300424.

Mathewson, H. A., M. L. Morrison, H. L. Loffland, and P. F. Brussard. 2013. Ecology of Willow Flycatchers (*Empidonax traillii*) in the Sierra Nevada, California: Effects of Meadow Characteristics and Weather on Demographics. *Ornithological Monographs* 75:1–32.

Mcfarland, T. M., C. Van Riper, and G. E. Johnson. 2012. Evaluation of NDVI to assess avian abundance and richness along the upper San Pedro River. *Journal of Arid Environments* 77:45–53.

Mora, M. A. 2003. Heavy metals and metalloids in egg contents and eggshells of passerine birds from Arizona. *Environmental Pollution* 125:393–400.

Nishida, C., and N. Schroeder. 2008. Restoring Endangered Species on the Pueblo of Santa Ana. *Endangered Species Update* 25:4.

Owen, J. C., M. K. Sogge, and M. D. Kern. 2005. Habitat and Sex Differences in Physiological Condition of Breeding Southwestern Willow Flycatchers (*Empidonax Traillii extimus*). *The Auk* 1261–1270:11.

Paxton, E. H., T. C. Theimer, and M. K. Sogge. 2011. Tamarisk Biocontrol Using Tamarisk Beetles: Potential Consequences for Riparian Birds in the Southwestern United States. *The Condor* 113:255–265.

Rothstein, S. I., B. E. Kus, M. J. Whitfield, and S. J. Sferra. 2003. Recommendations for Cowbird Management in Recovery Efforts for the Southwestern Willow Flycatcher. *Studies in Avian Biology* 26:157–167.

Rubin, Z., B. Rios-Touma, G. M. Kondolf, M. E. Power, P. Saffarinia, and J. Natali. 2019. Using prey availability to evaluate Lower Colorado River riparian restoration. *Restoration Ecology* 27:46–53.

Schofield, L., H. Loffland, R. Siegel, C. Stermer, and H. Mathewson. 2018. Using conspecific broadcast for Willow Flycatcher restoration. *Avian Conservation and Ecology* 13. <https://www.ace-eco.org/vol13/iss1/art23/>. Accessed 15 Jan 2019.

Shafroth, P. B., J. R. Cleverly, T. L. Dudley, J. P. Taylor, C. Van Riper, E. P. Weeks, and J. N. Stuart. 2005. Control of *Tamarix* in the Western United States: Implications for Water Salvage, Wildlife Use, and Riparian Restoration. *Environmental Management* 35:231–246.

Smith, D. M., and D. M. Finch. 2014. Use of Native and Nonnative Nest Plants by Riparian-Nesting Birds Along Two Streams in New Mexico: Riparian Nest Plant Use. *River Research and Applications* 30:1134–1145.

Smith, D. M., J. F. Kelly, and D. M. Finch. 2007. Avian Nest Box Selection and Nest Success in Burned and Unburned Southwestern Riparian Forest. *Journal of Wildlife Management* 71:411–421.

Sogge, M. K., S. J. Sferra, T. D. McCarthey, S. O. Williams, and B. E. Kus. 2003. Distribution and Characteristics of Southwestern Willow Flycatcher Breeding Sites and Territories: 1993–200. *Studies in Avian Biology* 26:5–11.

Sogge, M. K., S. J. Sferra, and E. H. Paxton. 2008. *Tamarix* as Habitat for Birds: Implications for Riparian Restoration in the Southwestern United States. *Restoration Ecology* 16:146–154.

Stoleson, S. H., and D. M. Finch. 1999. Unusual nest sites for southwestern Willow Flycatchers. *The Wilson Bulletin* 111:574–575.

Stoleson, S. H., and D. M. Finch. 2003. Microhabitat use by breeding Southwestern Willow Flycatchers on the Gila River, New Mexico. *Studies in Avian Biology* 26:91–95.

Stromberg, J. C. 2001. Restoration of riparian vegetation in the south-western United States: importance of flow regimes and fluvial dynamism. *Journal of Arid Environments* 49:17–34.

Stromberg, J. C., V. B. Beauchamp, M. D. Dixon, S. J. Lite, and C. Paradzick. 2007. Importance of low-flow and high-flow characteristics to restoration of riparian vegetation along rivers in arid south-western United States. *Freshwater Biology* 52:651–679.

Stumpf, K. J., T. C. Theimer, M. A. McLeod, and T. J. Koronkiewicz. 2012. Distance From Riparian Edge Reduces Brood Parasitism of Southwestern Willow Flycatchers, Whereas Parasitism Increases Nest Predation Risk. *The Journal of Wildlife Management* 76:269–277.

Theimer, T. C., M. K. Sogge, and E. H. Paxton. 2018. Patch age since disturbance drives patch dynamics for flycatchers breeding in both reservoir and riverine habitat. *Ecosphere* 9:e02425.

Werner, W. E. 2018. Chapter 8. Arizona as a Watershed Then and Now Case Studies of Changed Management of Rivers and Habitat in the Lower Colorado River System. Page 14 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Whitfield, M. J., K. M. Enos, and S. P. Rowe. 1999. Is Brown-headed Cowbird Trapping Effective for Managing Populations of the Endangered Southwestern Willow Flycatcher? *Studies in Avian Biology* 18:260–266.

Wiesenborn, W. D., and S. L. Heydon. 2007. Diets of Breeding Southwestern Willow Flycatchers in Different Habitats. *The Wilson Journal of Ornithology* 119:547–557.

Woodward, H. D., and S. H. Stoleson. 2002. Brown-Headed Cowbird Attacks Southwestern Willow Flycatcher Nestlings. *The Southwestern Naturalist* 47:626–628.

Yong, W., and D. M. Finch. 1997. Migration of the Willow Flycatcher along the Middle Rio Grande. *The Wilson Bulletin* 109:253–268.

York, P., P. Evangelista, S. Kumar, J. Graham, C. Flather, and T. Stohlgren. 2011. A habitat overlap analysis derived from Maxent for tamarisk and the south-western willow flycatcher. *Frontiers in Earth Science* 5:120–129.

Other Literature Cited

Ahlers, D., V. Johanson, S. Ryan, and R. Siegle. 2010. Southwestern Willow Flycatcher Habitat Suitability 2008: Highway 60 Downstream to Elephant Butte Reservoir, NM. U.S. Bureau of Reclamation.

Arizona Game and Fish Department. 2004. Mapping and Monitoring Southwestern Willow Flycatcher Breeding Habitat in Arizona: A Remote Sensing Approach. Nongame and Endangered Wildlife Technical Report, Arizona Game and Fish Department, Phoenix, AZ.

Bateman, H. L., and E. H. Paxton. 2009. Chapter 4: Saltcedar and Russian Olive Interactions with Wildlife. Saltcedar and Russian Olive Control and Demonstration Act Science Assessment, Scientific Investigations Report, U.S. Department of the Interior, U.S. Geological Survey.

Bloodworth, B. R., P. B. Shafroth, A. A. Sher, R. B. Manners, D. W. Bean, M. J. Johnson, and O. Hinojosa-Huerta. 2016. Tamarisk beetle (*Diorhabda* spp.) in the Colorado River basin: Synthesis of an expert panel forum. Scientific and Technical Report, Tamarisk Coalition, Grand Junction, CO. <http://tamariskcoalition.org/sites/default/files/files/Tamarisk_Beetle_Expert_Panel_Report.pdf>. Accessed 25 Sep 2017.

Brodhead, K. M. 2005. The influence of riparian-canopy structure and coverage on the breeding distribution of the Southwestern Willow Flycatcher. Montana State University-Bozeman, College of Letters & Science. <http://scholarworks.montana.edu/xmlui/handle/1/977>. Accessed 25 Sep 2017.

California Partners in Flight, and Riparian Habitat Joint Venture. 2004. The Riparian Bird Conservation Plan: A strategy for reversing the decline of riparian associated birds in California. <http://www.prbo.org/calpif/pdfs/riparian_v-2.pdf>. Accessed 15 Apr 2019.

Chenevert-Steffler, A. 2013. Statistical evaluation and GIS model development to predict and classify habitat quality for the endangered Southwestern Willow Flycatcher. Arizona State University, Tempe, AZ.

Copeland, S. L., R. D. Beane, C. E. Paradzick, and C. L. Sommers. 2009. Literature Review on Water Needs of the Southwestern Willow Fly Catcher. Literature Review, Prepared by ERO Resource Corp. Prepared for U.S. Bureau of Reclamation, Albuquerque, NM.

Durst, S. L. 2004. Southwestern Willow Flycatcher potential prey base and diet in native and exotic habitats. Northern Arizona University, Flagstaff, AZ.

Durst, S. L., M. K. Sogge, H. C. English, S. O. Williams III, B. E. Kus, and S. J. Sferra. 2006. Southwestern Willow Flycatcher Breeding Site and Territory Summary - 2005. Open-File Report, USGS Southwest Biological Science Center report to the U.S. Bureau of Reclamation.

Durst, S. L., M. K. Sogge, S. D. Stump, H. A. Walker, B. E. Kus, and S. J. Sferra. 2008. Southwestern Willow Flycatcher Breeding Site and Territory Summary - 2007. Open-File Report.

Durst, S. L., M. K. Sogge, S. D. Stump, S. O. Williams, B. E. Kus, and S. J. Sferra. 2007. Southwestern Willow Flycatcher Breeding Site and Territory Summary - 2006. Open-File Report, U.S. Geological Survey.

Finch, D. M. 1999. Recovering southwestern willow flycatcher populations will benefit riparian health. Pages 275–292 *in* R. E. McCabe and S. E. Loos, editors. *Transactions of the 64th North American Wildlife and Natural Resource Conference*.

Finch, D. M., and J. F. Kelly. 1999*a*. Rio Grande ecosystems: linking land, water, and people. Toward a sustainable future for the Middle Rio Grande Basin. Page 7 *in*. *USDA Forest Service Proceedings*.

Finch, D. M., and J. F. Kelly. 1999*b*. Status and migration of the Southwestern Willow Flycatcher in New Mexico. Pages 197–203 *in*. RMRS-P-7. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT.

Finch, D. M., and S. H. Stoleson. 2000*a*. Chapter 3: Threats. Status, ecology, and conservation of the Southwestern Willow Flycatcher, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ft. Collins, CO. <https://www.fs.usda.gov/treesearch/pubs/4568>. Accessed 26 Apr 2019.

Finch, D. M., and S. H. Stoleson. 2000*b*. Status, ecology, and conservation of the southwestern willow flycatcher. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ft. Collins, CO. <https://www.fs.usda.gov/treesearch/pubs/4568>. Accessed 11 Apr 2019.

Friggens, M. M., R. Loehman, L. Holsinger, and D. Finch. 2014. Vulnerability of riparian obligate species to the interactive effect of fire, climate and hydrological change. Final Report, USDA Forest Service Rocky Mountain Research Station. <https://www.fs.usda.gov/treesearch/pubs/49551>. Accessed 30 Jan 2018.

Guilfoyle, M. P., and R. A. Fischer. 2006. Guidelines for Establishing Monitoring Programs to Assess the Success of Riparian Restoration Efforts in Arid and Semi-Arid Landscapes. Engineer Research and Development Center, Vicksburg, MS.

Guilfoyle, M. P. 2001. Sensitive Western Riparian Songbirds Potentially Impacted by USACE Reservoir Operations. EMRRP Technical Notes Collection, U.S. Army Engineer Research and Development Center, Ecosystem Management and Restoration Research Program, Vicksburg, MS.

Hamilton, S. G. 2014. Effect of Hydrologic, Geomorphic, and Vegetative Conditions on Avian Communities in the Middle Rio Grande of New Mexico. Louisiana State University and Agricultural and Mechanical College.

Hatten, J. R. 2016. A Satellite model of Southwestern Willow Flycatcher (*Empidonax traillii extimus*) Breeding Habitat and a Simulation of Potential Effects of Tamarisk Leaf Beetles (*Diorhabda* spp.), Southwestern United States. Open-File Report, Southwestern United States: U.S. Geological Survey.

Hatten, J. R., and M. K. Sogge. 2007. Using a remote sensing/GIS model to predict Southwestern willow flycatcher breeding habitat along the Rio Grande, New Mexico. US Geological Survey Open-File Report 1207:27.

Hinojosa-Huerta, O. 2006. Birds, Water, and Saltcedar: Strategies for Riparian Restoration in the Colorado River Delta.

Moore, D. 2005. Status and Monitoring of Southwestern Willow Flycatchers within Elephant Butte Reservoir, New Mexico. Prepared by Technical Service Center, Ecological Planning and Assessment Group. Prepared for U.S. Bureau of Reclamation.

Moore, D. 2007. Vegetation Quantification of Southwestern Willow Flycatcher Nest Sites. Prepared by Technical Service Center, Ecological Planning and Assessment Group. Prepared for U.S. Bureau of Reclamation.

Paxton, E. H., M. K. Sogge, S. L. Durst, T. C. Theimer, and J. R. Hatten. 2007. The Ecology of the Southwestern Willow Flycatcher in Central Arizona - a 10-year Synthesis Report. Open-File Report, U.S. Geological Survey in cooperation with Northern Arizona University.

Paxton, Eben H., M. K. Sogge, T. C. Theimer, J. Girard, and P. Keim. 2008. Using molecular genetic markers to resolve a subspecies boundary: the northern boundary of the Southwestern Willow Flycatcher in the four-corner states. Open File Report, U.S. Geological Survey. <http://rgdoi.net/10.13140/RG.2.1.2008.5840>. Accessed 22 May 2019.

Peterson, D., A. R. Pellegrini, M. A. McLeod, and T. Theimer. 2015. Distance to standing water is negatively correlated with invertebrate biomass, nestling feeding rate, and productivity in southwestern willow flycatchers (*Empidonax traillii extimus*). Pages 262–270 *in*. The Colorado Plateau VI: Science and Management at the Landscape Scale. University of Arizona Press, Tucson, AZ. <https://nau.pure.elsevier.com/en/publications/distance-to-standing-water-is-negatively-correlated-with-inverteb>. Accessed 6 May 2019.

Rourke, J. W., T. D. McCarthey, R. F. Davidson, and A. M. Santaniello. 1999. Southwestern Willow Flycatcher Nest Monitoring Protocol. Nongame and Endangered Wildlife Program Technical Report, Arizona Game and Fish Department, Phoenix, AZ.

Smalls, Z. 2017. Effects of managed livestock grazing on potential habitat of Southwestern Willow Flycatchers in west-central Arizona. University of Arizona, Tucson, AZ.

Smith, A. B., P. E. T. Dockens, A. A. Tudor, H. C. English, and B. L. Allen. 2004. Southwestern Willow Flycatcher 2003 Survey and Nest Monitoring Report. Technical Report, Nongame Branch, Wildlife Management Division, Arizona Game and Fish Department.

Sogge, M. K., D. Ahlers, and S. J. Sferra. 2010. A Natural History Summary and Survey Protocol for the Southwestern Willow Flycatcher. Techniques and Methods, U.S. Geological Survey; prepared in cooperation with Bureau of Reclamation and the U.S. Fish and Wildlife Service.

Sogge, M. K., and R. M. Marshall. 2000. Chapter 5: A Survey of Current Breeding Habitats. Status, ecology, and conservation of the southwestern willow flycatcher, General Technical Report, USDA Forest Service, Rocky Mountain Research Station, Ogden, UT.

Sogge, M. K., R. M. Marshall, S. J. Sferra, and T. J. Tibbitts. 1997. A Southwestern Willow Flycatcher Natural History Summary and Survey Protocol. Technical Report. <http://www.rosemonteis.us/files/references/045649.pdf>. Accessed 10 Apr 2019.

Sogge, M. K., E. H. Paxton, and A. A. Tudor. 2006. Saltcedar and Southwestern Willow Flycatchers: Lessons from Long-term Studies in Central Arizona. Pages 238–241 *in* C. Aguirre-Bravo, P. J. Pellicane, D. P. Burns, and S. Draggan, editors. Monitoring Science and Technology Symposium: Unifying Knowledge for Sustainability in the Western Hemisphere Proceedings RMRS-P-42CD. Volume 42. U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Sogge, M. K., S. J. Sferra, T. McCarthey, S. O. Williams III, and B. E. Kus. 2001. Southwestern Willow Flycatcher Breeding Site and Territory Summary - 2000. Open-File Report, Prepared for The Southwestern Willow Flycatcher Recovery Team, U.S. Fish and Wildlife Service, Region 2, Albuquerque, NM.

Stake, M. 2007. 2007 Willow Flycatcher surveys at Bluewater Canyon, Lost Valley, and San Ysidro, New Mexico. Hawks Aloft, Inc. Submitted to Bureau of Land Management.

Stenquist, S. M., and J. Kauffeld. 2000. Saltcedar Integrated Weed Management and the Endangered Species Act. Pages 487–504 *in* N. R. Spencer, editor. *Proceedings of the X International Symposium on Biological Control of Weeds 4-14 July 1999*. Montana State University, Bozeman, WA.

Tetra Tech. 2015. Habitat Relationships Along the Middle Rio Grande in New Mexico for the Endangered Southwestern Willow Flycatcher. Prepared for U.S. Army Corps of Engineers.

U.S. Fish and Wildlife Service. 2002. Final Recovery Plan: Southwestern Willow Flycatcher (*Empidonax traillii extimus*). Prepared by Southwestern Willow Flycatcher Team Technical Subgroup for U.S. Fish and Wildlife Service Region 2, Albuquerque, NM. <https://www.fs.fed.us/rm/pubs_other/rmrs_2002_finch_d001.pdf>. Accessed 10 Apr 2019.

Woodward, H. 2007. Surveys for the Southwestern Willow Flycatcher in the Cliff-Gila Valley, New Mexico, May - July 2007. Final Report. <http://rgdoi.net/10.13140/RG.2.2.24305.12649>. Accessed 18 Apr 2019.

Middle Rio Grande Endangered Species Collaborative Program

Est. 2000

Bibliography of Yellow-billed Cuckoo Literature

Peer-Reviewed Literature Cited

Friggens, M. M., and D. M. Finch. 2015. Implications of Climate Change for Bird Conservation in the Southwestern U.S. under Three Alternative Futures. D. Russo, editor. *PLOS ONE* 10:e0144089.

Girvetz, E. H., and S. E. Greco. 2009. Multi-scale predictive habitat suitability modeling based on hierarchically delineated patches: an example for yellow-billed cuckoos nesting in riparian forests, California, USA. *Landscape Ecology* 24:1315–1329.

Greco, S. E., A. K. Fremier, E. W. Larsen, and R. E. Plant. 2007. A tool for tracking floodplain age land surface patterns on a large meandering river with applications for ecological planning and restoration design. *Landscape and Urban Planning* 81:354–373.

Johnson, M. J., J. R. Hatten, J. A. Holmes, and P. B. Shafroth. 2017. Identifying Western Yellow-Billed Cuckoo Breeding Habitat with a Dual Modelling Approach. *Ecological Modelling* 347:50–62.

Johnson, R. R., E. E. Johnson, and S. W. Carothers. 2018. Chapter 11. Terrestrial Vertebrates of Mesquite Bosques in Southwestern North America. Pages 188–211 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Mahoney, S. M., A. N. B. Smith, P. J. Motyka, E. J. Lundgren, R. R. Winton, B. Stevens, and M. J. Johnson. 2019. Russian olive habitat along an arid river supports fewer bird species, functional groups and a different species composition relative to mixed vegetation habitats. *Journal of Arid Environments* 167:26–33.

Mcfarland, T. M., C. Van Riper, and G. E. Johnson. 2012. Evaluation of NDVI to assess avian abundance and richness along the upper San Pedro River. *Journal of Arid Environments* 77:45–53.

McNeil, S. E., D. Tracy, and C. D. Cappello. 2015. Loop Migration by a Western Yellow-Billed Cuckoo Wintering in the Gran Chaco. *Western Birds* 46:244–255.

Nishida, C., and N. Schroeder. 2008. Restoring Endangered Species on the Pueblo of Santa Ana. *Tribal Conservation* 31–33.

Sechrist, J., D. D. Ahlers, K. P. Zehfuss, and R. H. Doster. 2013. Home Range and Use of Habitat of Western Yellow-billed Cuckoos on the Middle Rio Grande, New Mexico. *The Southwestern Naturalist* 58:411–419.

Smith, D. M., and D. M. Finch. 2014. Use of Native and Nonnative Nest Plants by Riparian-Nesting Birds Along Two Streams in New Mexico: Riparian Nest Plant Use. *River Research and Applications* 30:1134–1145.

Smith, D. M., J. F. Kelly, and D. M. Finch. 2006. Cicada Emergence in Southwestern Riparian Forest: Influences of Wildfire and Vegetation Composition. *Ecological Applications* 16:1608–1618.

Sogge, M. K., S. J. Sferra, and E. H. Paxton. 2008. *Tamarix* as Habitat for Birds: Implications for Riparian Restoration in the Southwestern United States. *Restoration Ecology* 16:146–154.

Villarreal, M. L., C. van Riper, and R. E. Petrakis. 2014. Conflation and aggregation of spatial data improve predictive models for species with limited habitats: A case of the threatened Yellow-billed Cuckoo in Arizona, USA. *Applied Geography* 47:57–69.

Wallace, C. S. A., M. L. Villarreal, and C. van Riper III. 2013. Influence of monsoon-related riparian phenology on Yellow-billed Cuckoo habitat selection in Arizona. R. Pearson, editor. *Journal of Biogeography* 40:2094–2107.

Werner, W. E. 2018. Chapter 8. Arizona as a Watershed Then and Now Case Studies of Changed Management of Rivers and Habitat in the Lower Colorado River System. Pages 134–147 *in*. Riparian research and management: Past, present, future: Volume 1. Gen. Tech. Rep. RMRS-GTR-377, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Other Literature Cited

Bateman, H. L., and E. H. Paxton. 2009. Chapter 4: Saltcedar and Russian Olive Interactions with Wildlife. Saltcedar and Russian Olive Control and Demonstration Act Science Assessment, Scientific Investigations Report, U.S. Department of the Interior, U.S. Geological Survey.

California Partners in Flight, and Riparian Habitat Joint Venture. 2004. The Riparian Bird Conservation Plan: A strategy for reversing the decline of riparian associated birds in California. California Partners in Flight and Riparian Habitat Joint Venture. <http://www.prbo.org/calpif/pdfs/riparian_v-2.pdf>. Accessed 15 Apr 2019.

Carstensen, D., D. D. Ahlers, and D. Moore. 2015. Yellow-billed Cuckoo Study Results - 2014. Prepared by Technical Service Center, Ecological Planning and Assessment Group. Prepared for U.S. Bureau of Reclamation, Denver, CO.

Dillon, K. G., D. Ahlers, and D. Moore. 2017. Yellow-billed Cuckoo Study Results - 2016: Middle Rio Grande from Los Lunas to Elephant Butte Reservoir, New Mexico. Technical Service Center Fisheries and Wildlife Resources Group; prepared for U.S. Bureau of Reclamation. <https://www.usbr.gov/tsc/techreferences/env/2016MRGYBCU%20REPORT_508.pdf>. Accessed 11 Apr 2019.

Friggens, M. M., R. Loehman, L. Holsinger, and D. Finch. 2014. Vulnerability of riparian obligate species to the interactive effect of fire, climate and hydrological change. Final Report, USDA Forest Service Rocky Mountain Research Station. <https://www.fs.usda.gov/treesearch/pubs/49551>. Accessed 30 Jan 2018.

Guilfoyle, M. P. 2001. Sensitive Western Riparian Songbirds Potentially Impacted by USACE Reservoir Operations. EMRRP Technical Notes Collection, U.S. Army Engineer Research and Development Center, Ecosystem Management and Restoration Research Program, Vicksburg, MS.

Hamilton, S. G. 2014. Effect of Hydrologic, Geomorphic, and Vegetative Conditions on Avian Communities in the Middle Rio Grande of New Mexico. Louisiana State University and Agricultural and Mechanical College.

Hinojosa-Huerta, O. 2006. Birds, Water, and Saltcedar: Strategies for Riparian Restoration in the Colorado River Delta.

Johnson, Matthew J. 2009. Understanding the Habitat Needs of the Declining Western Yellow-Billed Cuckoo. Fact Sheet, U.S. Geological Survey in cooperation with Northern Arizona University.

Johnson, M. J., S. L. Durst, C. M. Calvo, M. K. Sogge, G. Bland, and T. Arundel. 2008. Yellow-billed Cuckoo Distribution, Abundance, and Habitat Use Along the Lower Colorado River and its Tributaries, 2007 Annual Report. Open-File Report, U.S. Geological Survey.

Johnson, M. J., J. A. Holmes, C. Calvo, I. Samuels, S. Krantz, and M. K. Sogge. 2007. Yellow-Billed Cuckoo Distribution, Abundance, and Habitat Use Along the Lower Colorado and Tributaries, 2006 Annual Report. Open-File Report, U.S. Geological Survey.

McNeil, S. E. 2015. Population Genetic Diversity and Structure in Yellow-billed Cuckoos Across a Fragmented Landscape. University of Arizona.

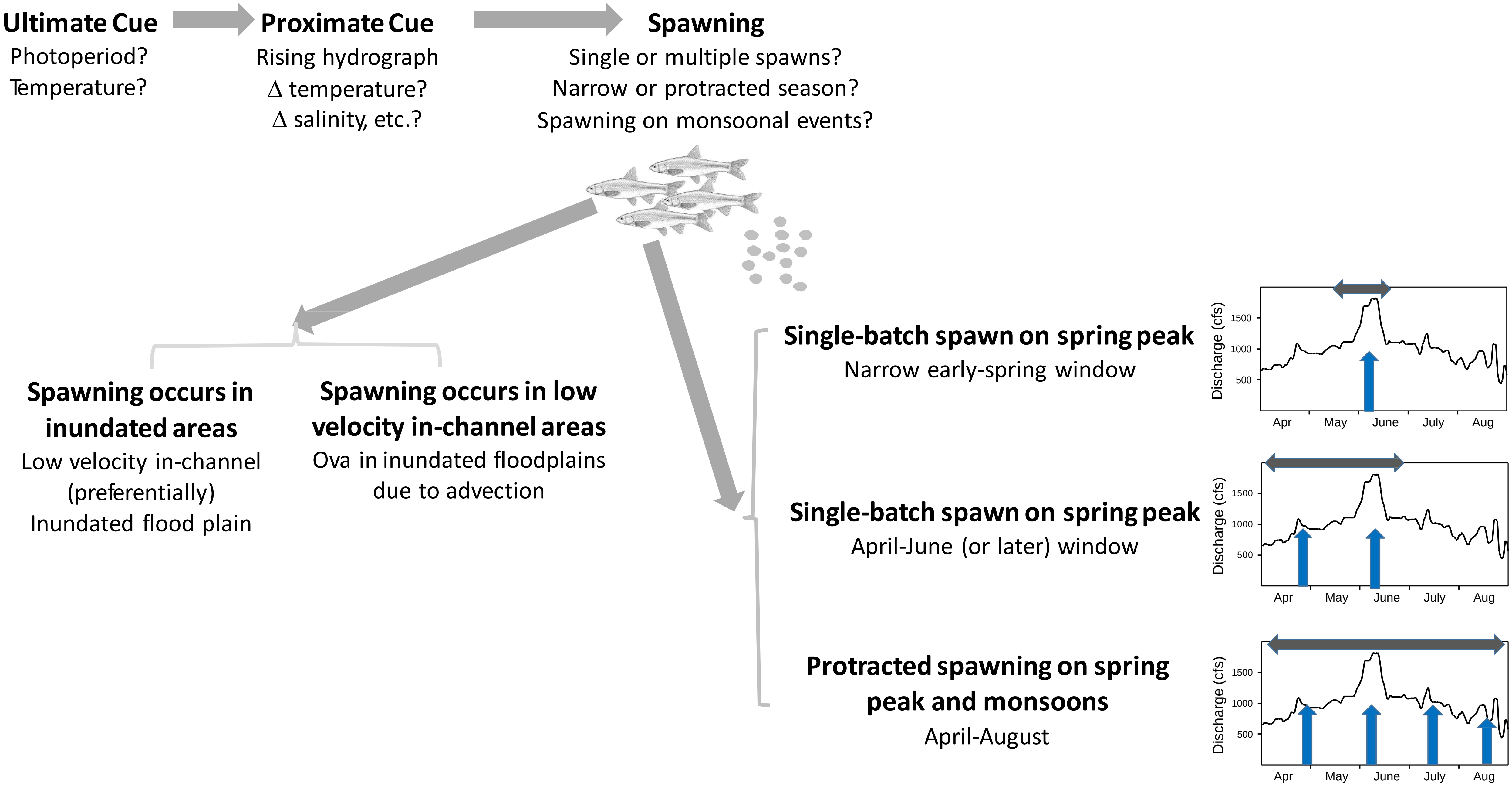
McNeil, S. E., D. Tracy, J. R. Stanek, and J. E. Stanek. 2012. Yellow-billed Cuckoo Distribution, Abundance and Habitat Use on the Lower Colorado River and Tributaries, 2011 Annual Report. Lower Colorado River Multi-Species Conservation Program.

Sechrist, J., V. Johanson, and D. Ashlers. 2009. Western Yellow-billed Cuckoo Radio Telemetry Study Results: Middle Rio Grande, New Mexico 2007-2008. U.S. Bureau of Reclamation, Albuquerque, NM.

Wallace, C. S. A., M. Villarreal, and C. van Riper. 2013. Mapping Landscape Phenology Preference of Yellow-Billed Cuckoo with AVHRR Data. Page 3 *in*. *USDA Forest Service Proceedings RMRS-P-67*.

Woodward, H. 2007. Surveys for the Southwestern Willow Flycatcher in the Cliff-Gila Valley, New Mexico, May - July 2007. Final Report. <http://rgdoi.net/10.13140/RG.2.2.24305.12649>. Accessed 18 Apr 2019.

Woodward, H. D., S. H. Stoleson, and D. M. Finch. 2003. Yellow-Billed Cuckoos on the Gila National Forest: Presence-Absence, Abundance, and Habitat. Final Report for the 2002 Field Season, Rocky Mountain Research Station, Albuquerque, NM.


Ultimate Cue
Photoperiod?
Temperature?
Proximate Cue
Rising hydrograph
Δ temperature?
Δ salinity, etc.?
Spawning
Single or multiple spawns?
Narrow or protracted season?
Spawning on monsoonal events?
Spawning occurs in inundated areas
Low velocity in-channel (preferentially)
Inundated flood plain
Spawning occurs in low velocity in-channel areas
Ova in inundated floodplains due to advection
Single-batch spawn on spring peak
Narrow early-spring window
Single-batch spawn on spring peak
April-June (or later) window
Protracted spawning on spring peak and monsoons
April-August
Discharge (cfs)
1500
1000
500
Apr
May
June
July
Aug
Discharge (cfs)
1500
1000
500
Apr
May
June
July
Aug
Discharge (cfs)
1500
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May
June
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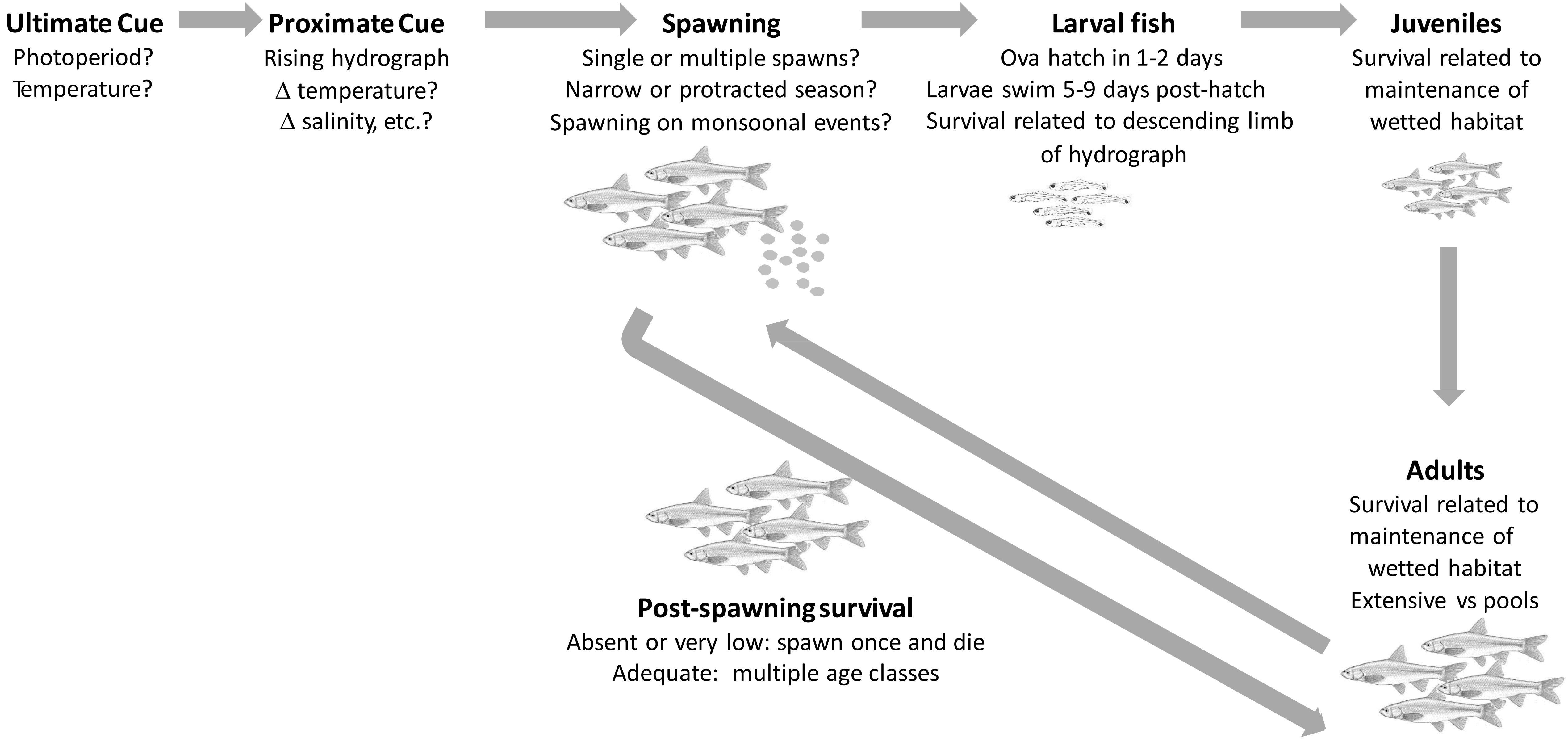
Aug


Ultimate Cue
Photoperiod?
Temperature?
Proximate Cue
Rising hydrograph
Δ temperature?
Δ salinity, etc.?
Spawning
Single or multiple spawns?
Narrow or protracted season?
Spawning on monsoonal events?
Larval fish
Ova hatch in 1-2 days
Larvae swim 5-9 days post-hatch
Survival related to descending limb of hydrograph
Juveniles
Survival related to maintenance of wetted habitat
Adults
Survival related to maintenance of wetted habitat
Extensive vs pools
Post-spawning survival
Absent or very low: spawn once and die
Adequate: multiple age classes

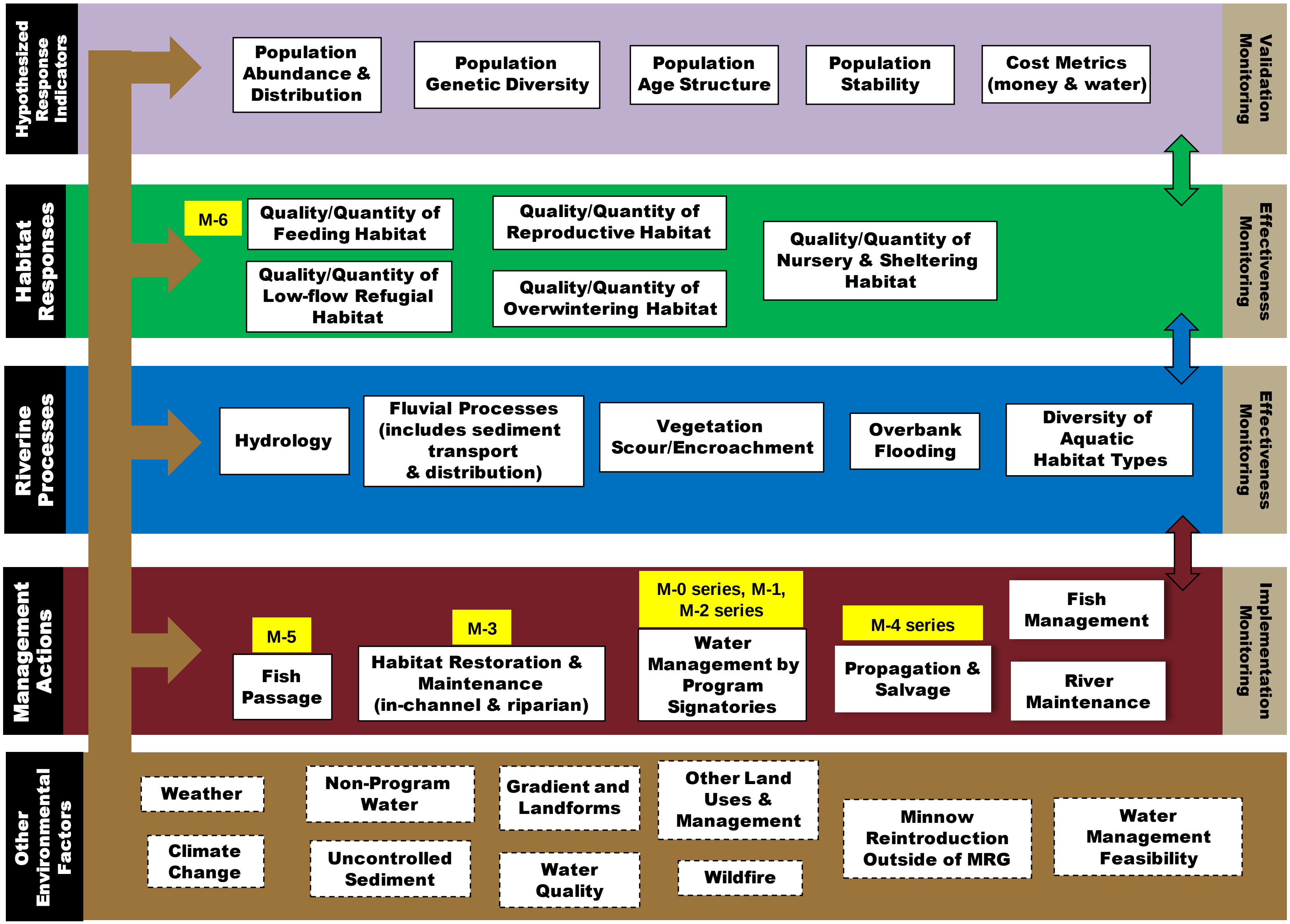


Figure 5. Conceptual model for the Rio Grande silvery minnow.

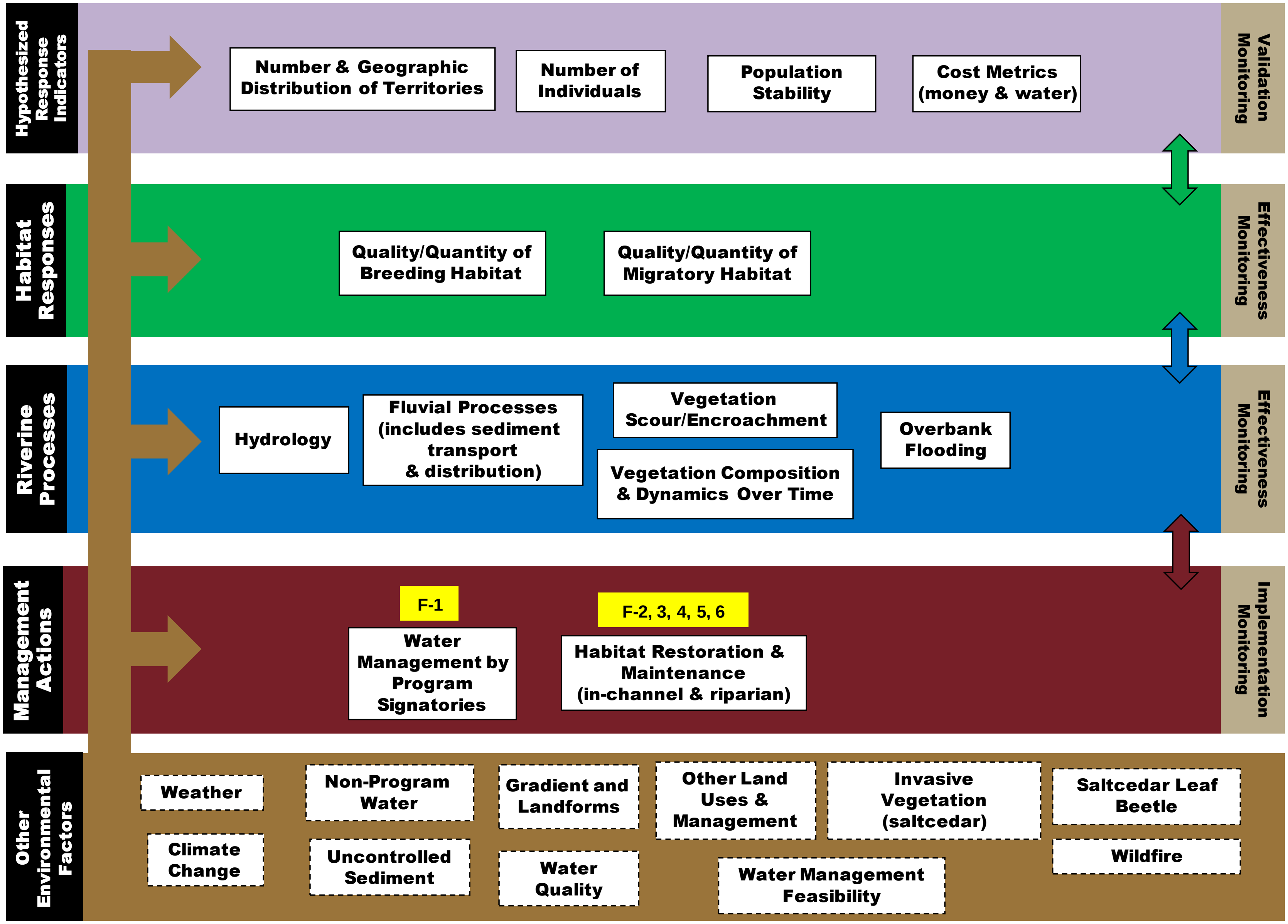


Figure 6. Conceptual model for the Southwestern Willow Flycatcher.

Rio Grande Silvery Minnow Conceptual Models

- Haggerty, G. 2019. Conceptual RGSM Model.
- Miller, P.S. 2008. *Population Viability Assessment for the Rio Grande silvery minnow.* IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, MN.
- Mortensen, J.G., R.K. Dudley, S.P. Platania, and T.F. Turner. 2019. Rio Grande silvery minnow biology and habitat syntheses. Final Report to U.S. Bureau Of Reclamation, American Southwest Ichthyological Researchers, Albuquerque, NM.
- Murray, C., C. Smith and D. Marmorek. 2011. Middle Rio Grande Endangered Species Collaborative Program Adaptive Management Plan Version 1. Prepared by ESSA Technologies Ltd. (Vancouver, BC) and Headwaters Corporation (Kearney, NE) for the Middle Rio Grande Endangered Species Collaborative Program, Albuquerque, NM.
- Noon, B., D. Hankin, T. Dunne, and G. Grossman. 2017. Independent Science Panel Findings Report: Rio Grande Silvery Minnow Key Scientific Uncertainties and Study Recommendations. Prepared for the U.S. Army Corps of Engineers, Albuquerque District on Behalf of the Middle Rio Grande Endangered Species Collaborative Program. Prepared by GeoSystems Analysis, Inc. Albuquerque, NM. June 2017. Contract No. W912PP-15-C-0008.
- Valdez, R.A. 2018. Adaptive Management Module.
- Yackulic, C.B. 2019. Developing an integrated population model for Rio Grande silvery minnow in the Middle Rio Grande. U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Flagstaff, AZ.

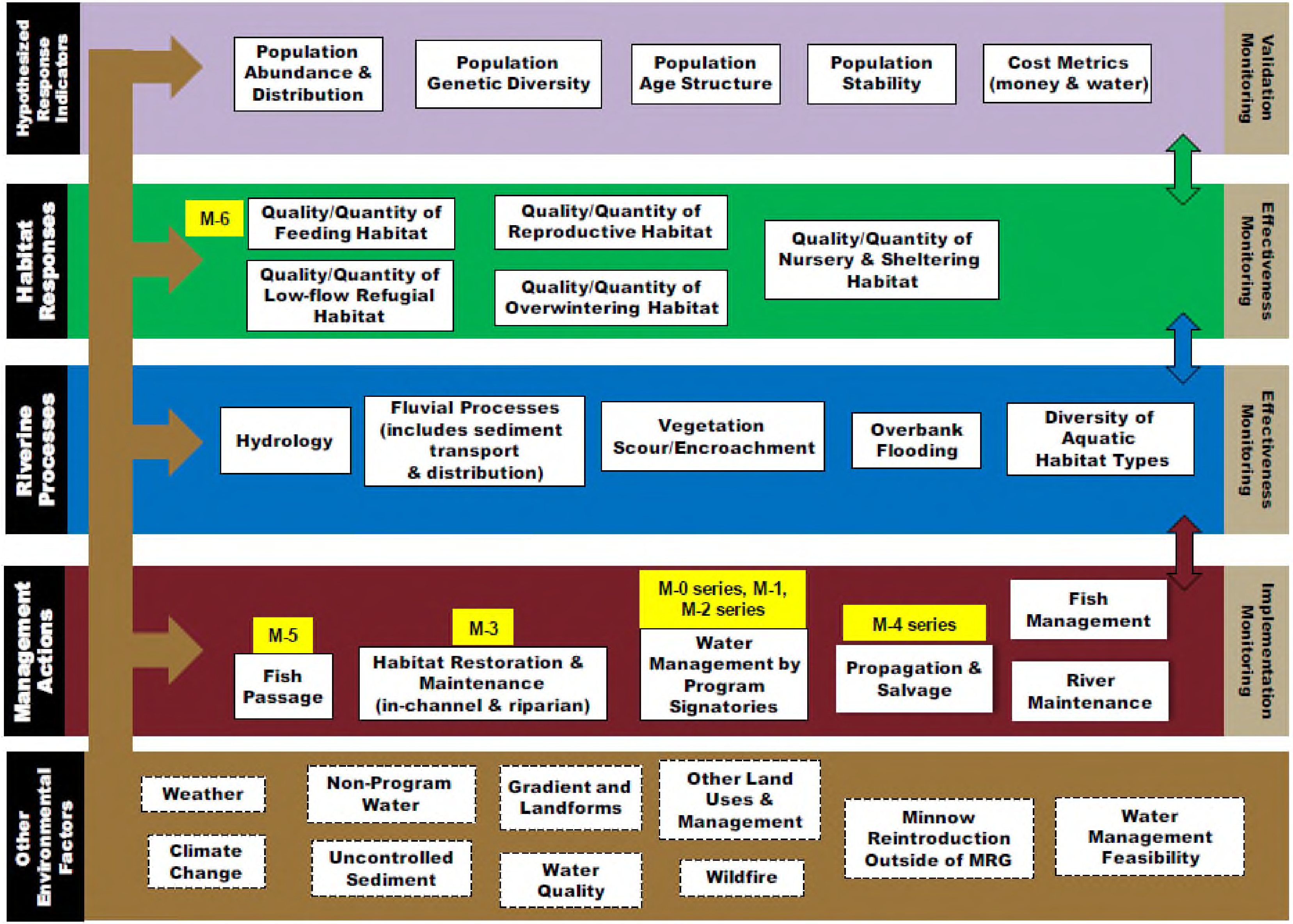
Miller, P.S. 2008. *Population Viability Assessment for the Rio Grande silvery minnow.*

$$\begin{bmatrix} N_0(t+1) \\ N_1(t+1) \end{bmatrix} = \begin{bmatrix} F_0 & F_1 \\ S_1 & 0 \end{bmatrix} \begin{bmatrix} N_0(t) \\ N_1(t) \end{bmatrix}$$

Leslie Matrix, where:

- $N_0(t+1)$ and $N_0(t)$ = numbers of individuals in age class 0 at time (t+1) and (t), respectively;
- F_0 = fecundity of age 0 individuals; and
- S_1 = survival rate of individuals in age class 1.
- Note value in the lower-right corner is automatically set to 0 because we assume that individuals do not live to see their third birthday.

Murray, C., C. Smith and D. Marmorek. 2011. Middle Rio Grande Endangered Species Collaborative Program Adaptive Management Plan Version 1. Conceptual model for the Rio Grande silvery minnow.



Noon, B., D. Hankin, T. Dunne, and G. Grossman. 2017. Independent Science Panel Findings Report: Rio Grande Silvery Minnow Key Scientific Uncertainties and Study Recommendations.

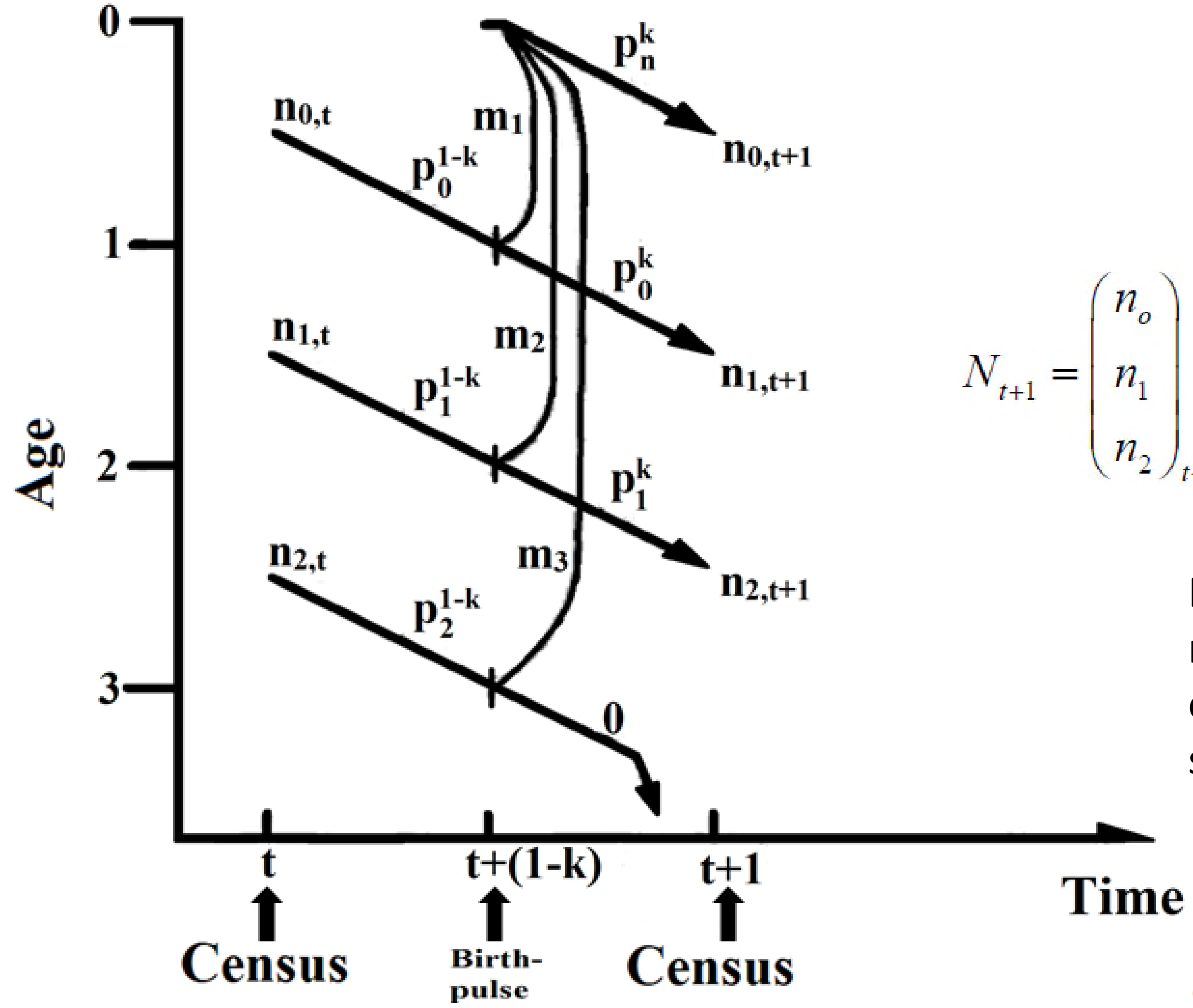


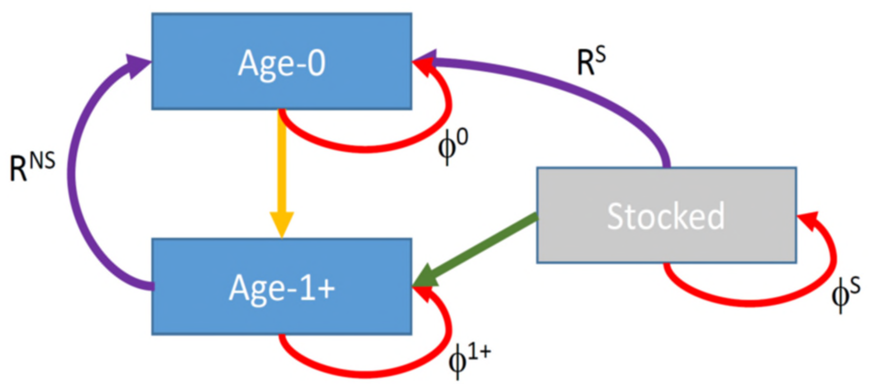
Figure 3. A general time-by-age biplot showing cohort transitions between census periods.

$$N_{t+1} = \begin{pmatrix} n_o \\ n_1 \\ n_2 \end{pmatrix}_{t+1} = \begin{pmatrix} p_0^{1-k} m_1 p_0^k & p_1^{1-k} m_2 p_0^k & p_2^{1-k} m_3 p_0^k \\ p_0^{1-k} p_0^k & 0 & 0 \\ 0 & p_1^{1-k} p_1^k & 0 \end{pmatrix} \begin{pmatrix} n_0 \\ n_1 \\ n_2 \end{pmatrix}_t = LN_t$$

Example projection matrix for Rio Grande silvery minnow, assuming the “census” to occur some fraction *k* of the year following the spawning birth-pulse.

Yackulic, C.B. 2019. Developing an integrated population model for Rio Grande silvery minnow in the Middle Rio Grande

ϕ^{0}	Age-0 monthly survival
ϕ^{1+}	Age-1+ monthly survival
ϕ^{S}	Stocked monthly survival
R^{S}	reproductive rate - stocked
R^{NS}	reproductive rate - not stocked



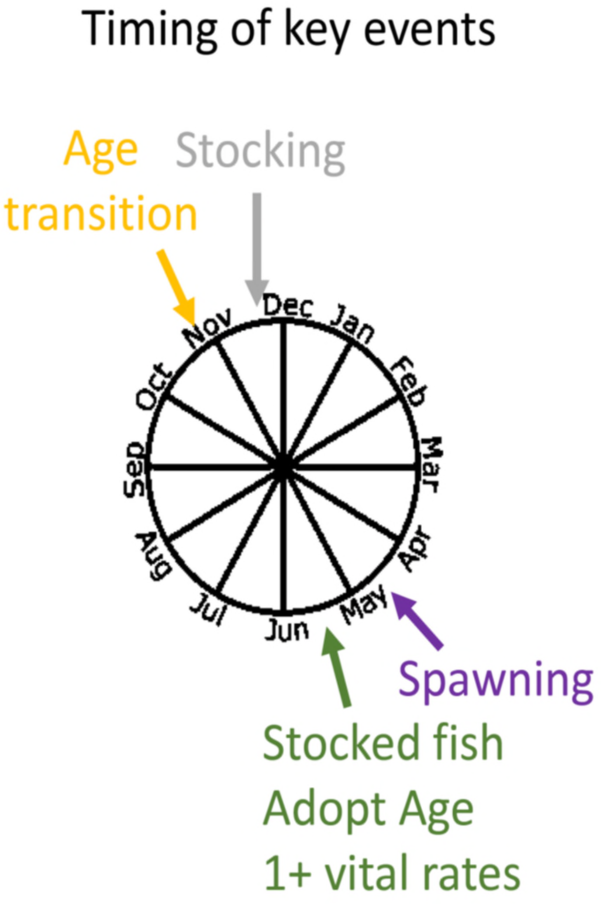


Figure 1: Schematic representation of RGSM demographics, including definition of key vital rates, representation of transitions between three states represented in the model, and timing of key events over the course of a calendar year.

Yackulic, C.B. 2019. Developing an integrated population model for Rio Grande silvery minnow in the Middle Rio Grande

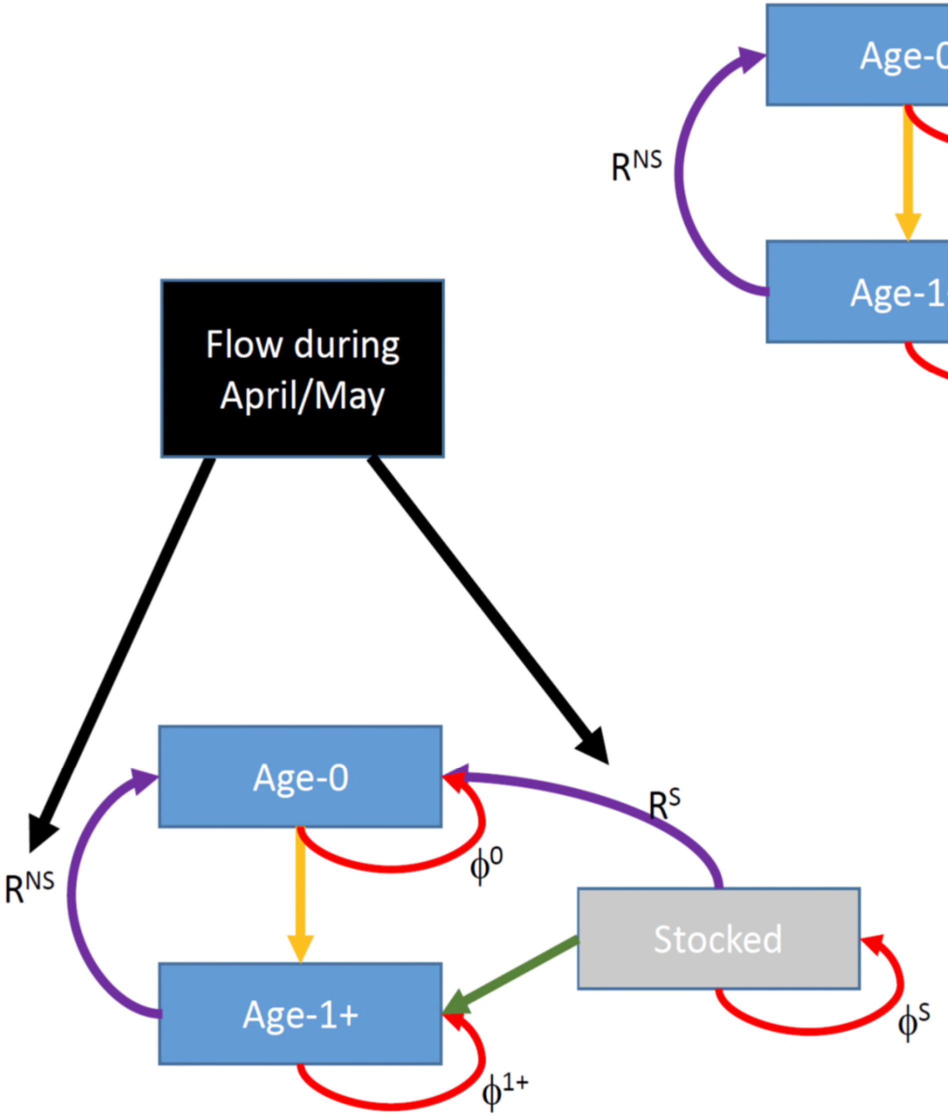
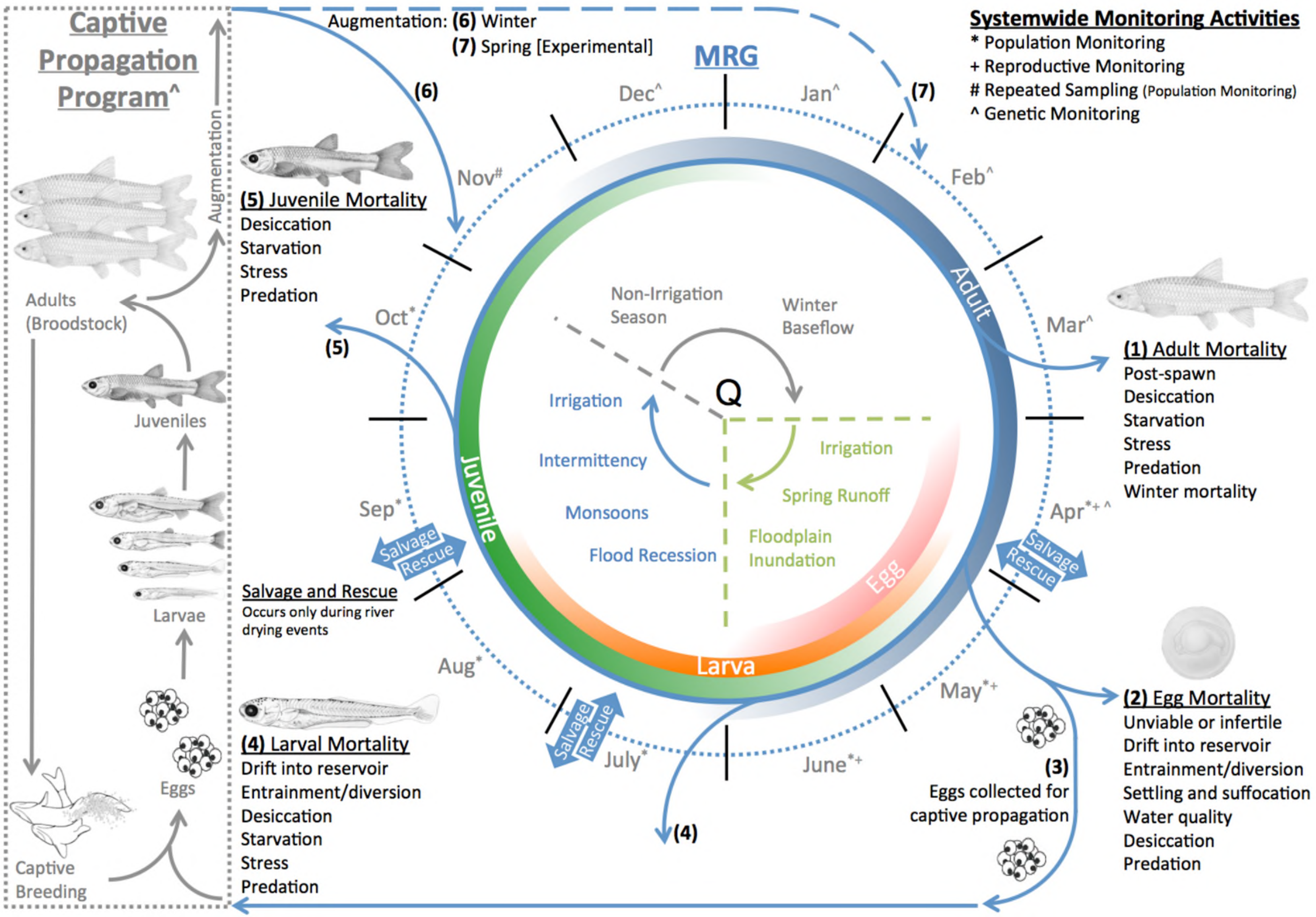
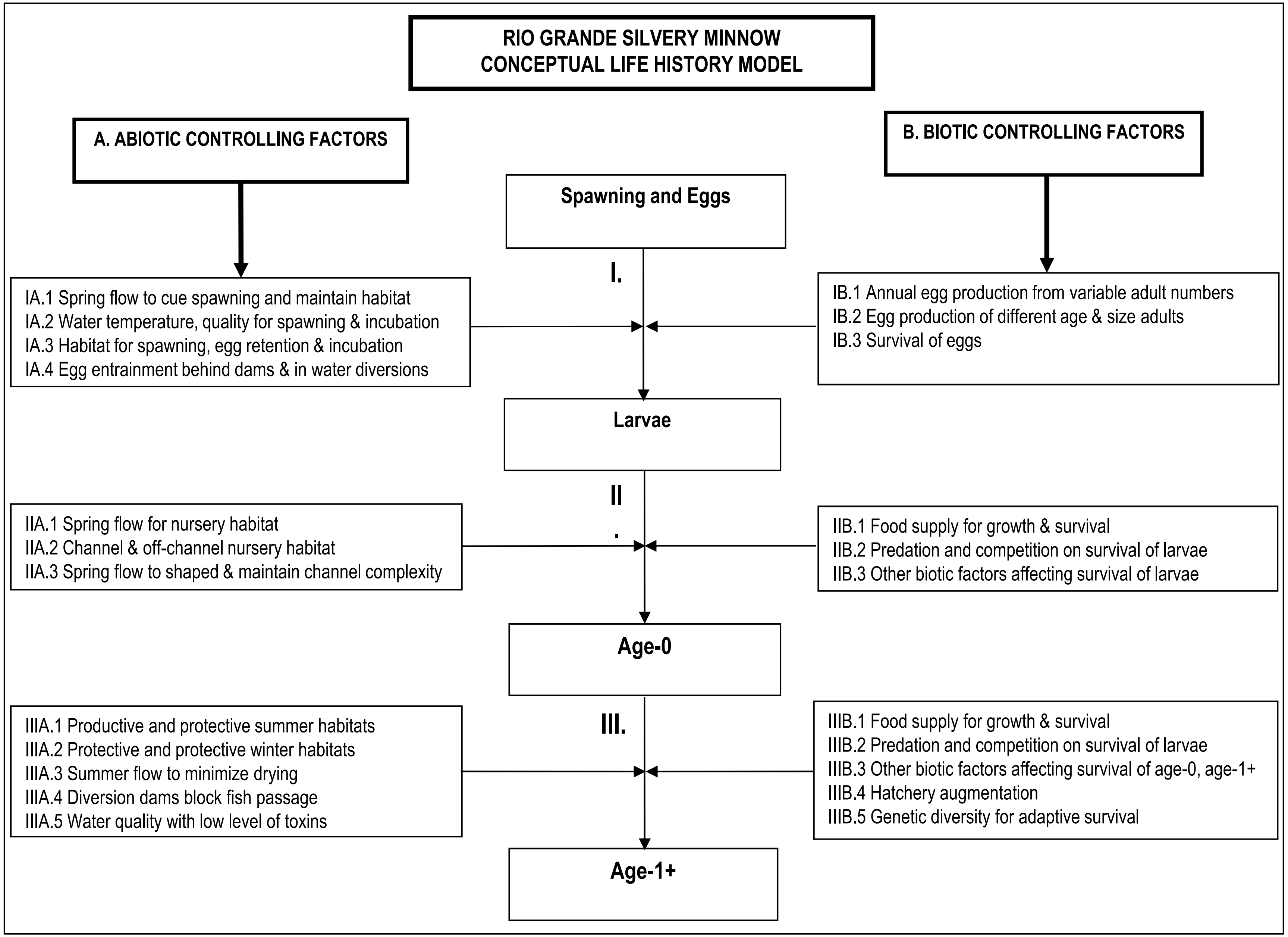


Figure 2: Examples of hypotheses for different demographic rates. (lower left-hand) Managers may be interested in how well different aspects of flow correspond to temporal variation in recruitment. Strength of evidence for different predictors can be calculated using metrics like multilevel R^2. If competing predictors are highly correlated and imply very different management, it may be worthwhile to consider a set of covariates (instead of just the "best" one) in making decisions and it may even be worthwhile to design experiments to disentangle these covariates. (upper right-hand) Managers may also want to consider hypotheses related to various potential drivers of over-summer survival in both Age-0 and Age-1+RGSM.

Mortensen, J.G., R.K. Dudley, S.P. Platania, and T.F. Turner. 2019. Rio Grande silvery minnow biology and habitat syntheses. Final Report, U.S. Bureau Of Reclamation



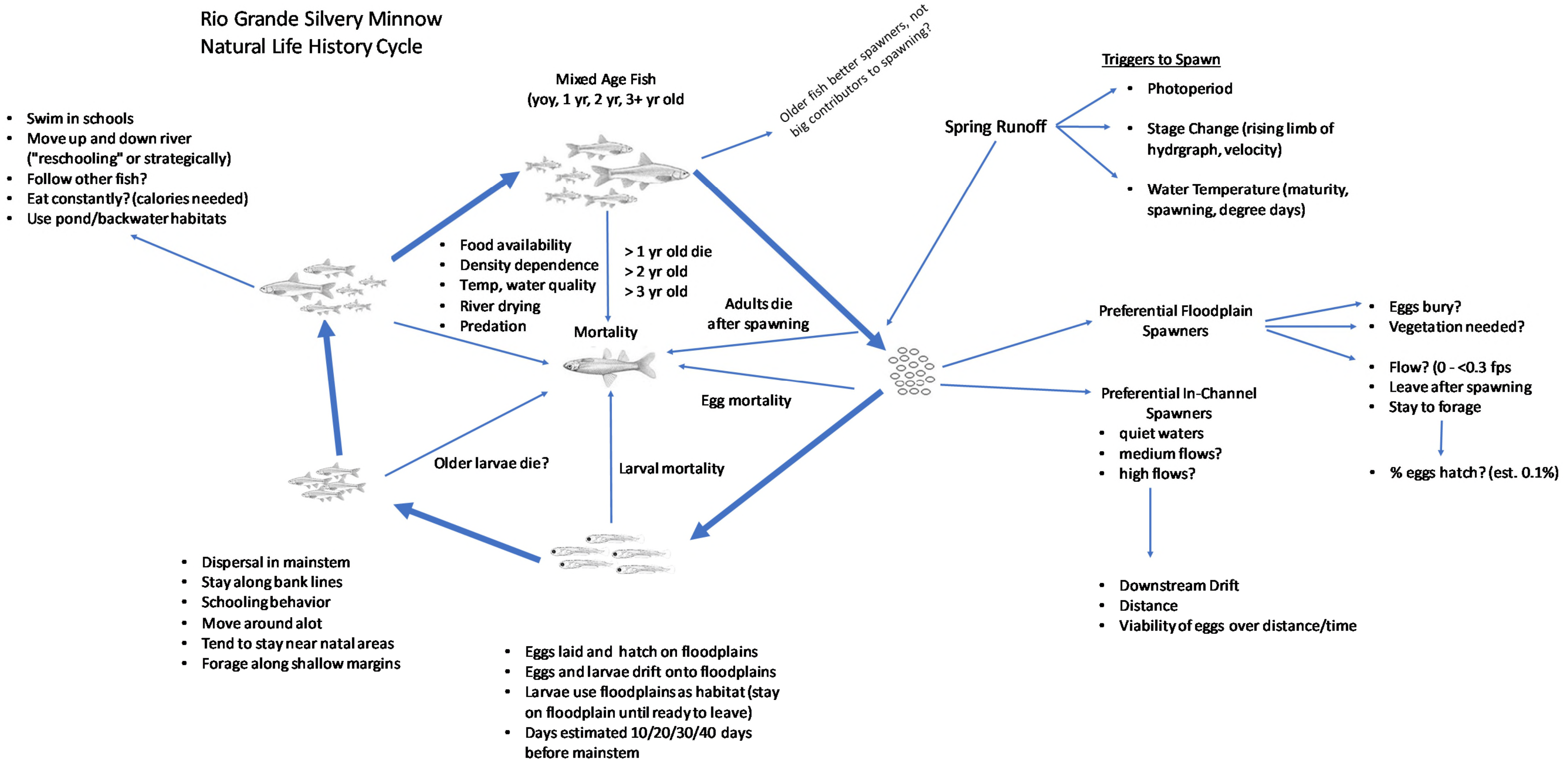
Valdez, R.A. 2018. Adaptive Management Module



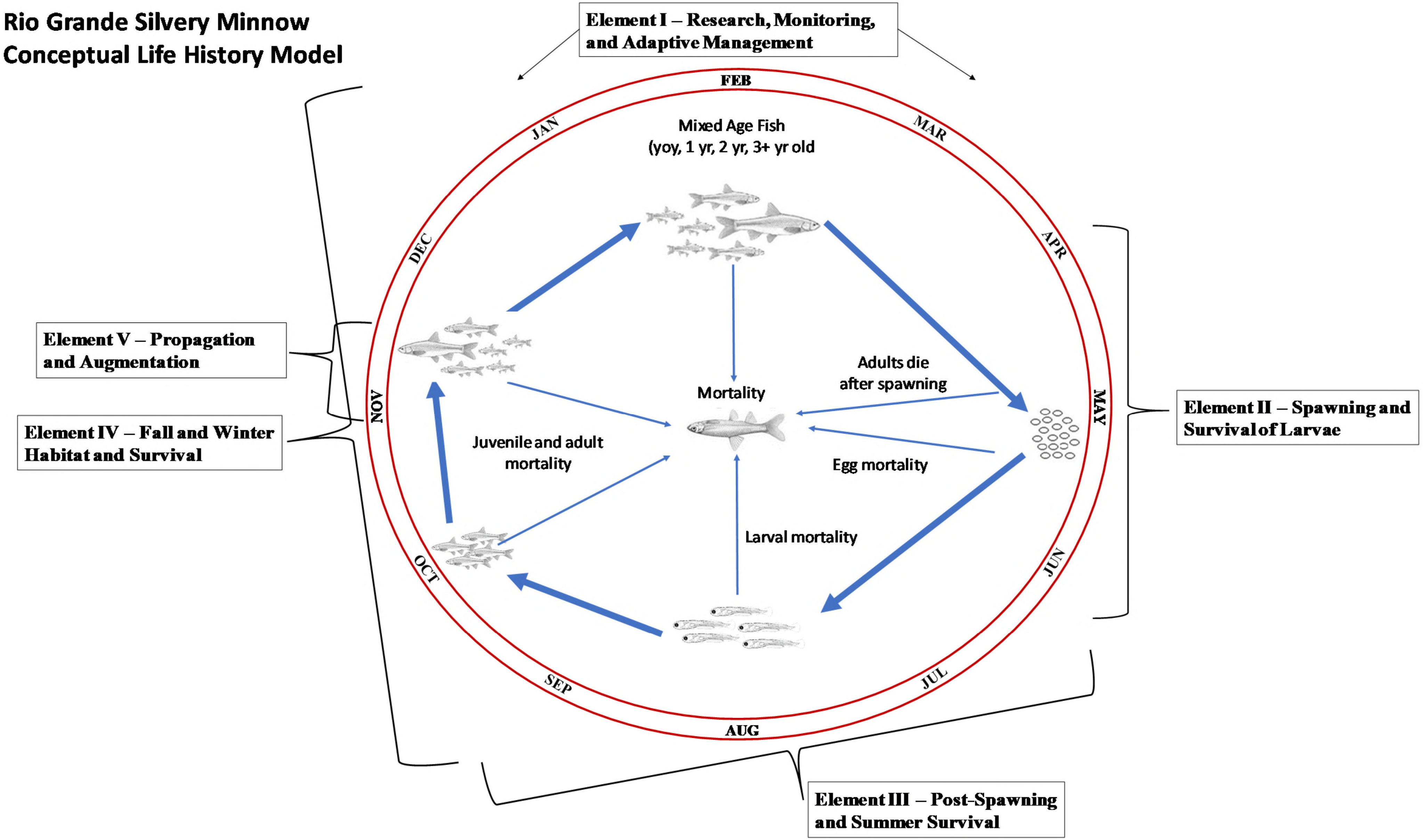
Valdez, R.A. 2019. Adaptive Management Module.

I. Spawning and Eggs to Larvae A Abiotic Factors	Critical Uncertainties	A Priori Assumptions
IA.1 Spring flow to cue spawning and maintain habitat	IA.1-1 What flow is needed to cue spawning?	IA.1-1a High spring flow is needed to cue spawning. IA.1-1b Flow spikes are more important than magnitude to cue spawning
	IA.1-2 What flow is needed to maintain spawning habitat?	IA.1-2a High spring flow is needed to maintain spawning habitat. IA.1-2b Spawning occurs at a range of flows.
IA.2 Water temperature, quality for spawning & incubation	IA.2-1 How does water temperature affect spawning & egg incubation?	IA.2-1a Temperature degree-days determine spawning readiness. IA.2-1b Spawning readiness is determined by a temperature threshold.
	IA.2-2 What other water quality factors affect spawning & egg incubation?	IA.2-2 Turbidity, salinity determine time of spawning and affect egg buoyancy.
IA.3 Habitat for spawning, egg retention & incubation	IA.3-1 Where does spawning occur?	IA.3-1a Spawning in the mainstem results in downstream transport of eggs. IA.3-1b Spawning in floodplains helps to retain eggs & larvae near natal areas.
	IA.3-2 Where is egg survival highest?	IA.3-2a Egg survival is lower in the mainstem. IA.3-2b Egg survival is higher in floodplains.
	IA.3-3 How long should floodplains persist for spawning & incubation	IA.3-3 Floodplains should persist 30 days for spawning & incubation.
IA.4 Egg entrainment behind dams & in water diversions	IA.4-1 How significant is egg entrainment behind dams?	IA.4-1 Egg entrainment behind dams is not significant to total egg production.
	IA.4-2 How significant is egg entrainment in water diversions?	IA.4-2 Egg entrainment in diversions is not significant to total egg production.
A Biotic Factors		
IB.1 Annual egg production from variable adult numbers	IB.1-1 What is effect of prior Oct CPUEs on egg production & cohort strength?	IB.1-1a Egg production is significantly correlated to 1-3 years prior Oct CPUEs. IB.1-1b Egg production is linked to floodplain inundation and egg retention.
IB.2 Egg production of different age & size adults	IB.2-1 What is effect of age & size on egg production?	IB.2-1a Older fish contribute more to egg production in years of low fish numbers. IB.2-1b Older fish are too few to contribute significantly to egg production.
IB.3 Survival of eggs	IB.3-1 How significant is downstream transport to total egg production?	IB.3-1a Downstream loss of eggs from the system is significant to total egg production. IB.3-1b Abrasion of eggs in transport is significant to egg survival.
	IB.3-2 How significant is fish predation to egg survival?	IB.3-2 Fish predation is significant to egg survival.

Haggerty, G.M. 2019. Example of Conceptual RGSM Model.



Haggerty, G.M. and R.A. Valdez. 2019. Revised Conceptual RGSM Model.



SWFL LIFE STAGE 1 – NEST

The nest stage lasts from when the egg is laid until either the young fledge or the nest fails. Success during this life stage – successful transition to the juvenile stage – involves organism survival, maturation, molt, and fledging. The organisms actively interact with their environment.

The CEM (figures 3 and 4) recognizes five (of nine) critical biological activities and processes for this life stage, ordered here as they appear on the following figures:

1. **Disease** – Although the literature does not emphasize disease as affecting population levels of SWFL, we still feel that disease bears mentioning, and it has been recommended as an area for further research (Paxton et al. 2007).

   The CEM recognizes genetic diversity and infectious agents as a habitat element affecting disease.

2. **Eating** – The nestling must eat to maintain metabolic processes.

   The CEM recognizes brood size and parental nest attendance as habitat elements affecting eating (feeding young).

3. **Nest Predation and Brood Parasitism** – Both nest predation and brood parasitism affect the survival of a nest and are affected by similar habitat elements. Brood parasitism has been identified as a threat to SWFL (Marshall and Stoleson 2000), although it likely only threatens small populations (Finch et al. 2002). We have therefore combined nest predation and brood parasitism into one process for this stage.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, intermediate structure, linear width of patch, nest predator and cowbird density, parental nest attendance, patch size, and tree density as habitat elements affecting nest predation and brood parasitism.

4. **Molt** – The nestling must molt into juvenal plumage.

   The CEM does not recognize any habitat elements as directly affecting molt. Other critical biological activities and processes influencing molt include those affecting energy resources such as disease and eating.

5. **Temperature Regulation** – The eggs and nestlings must maintain an optimum temperature to develop and survive.

   The CEM recognizes canopy closure, humidity, intermediate structure, parental nest attendance, and temperature as habitat elements directly affecting temperature regulation.

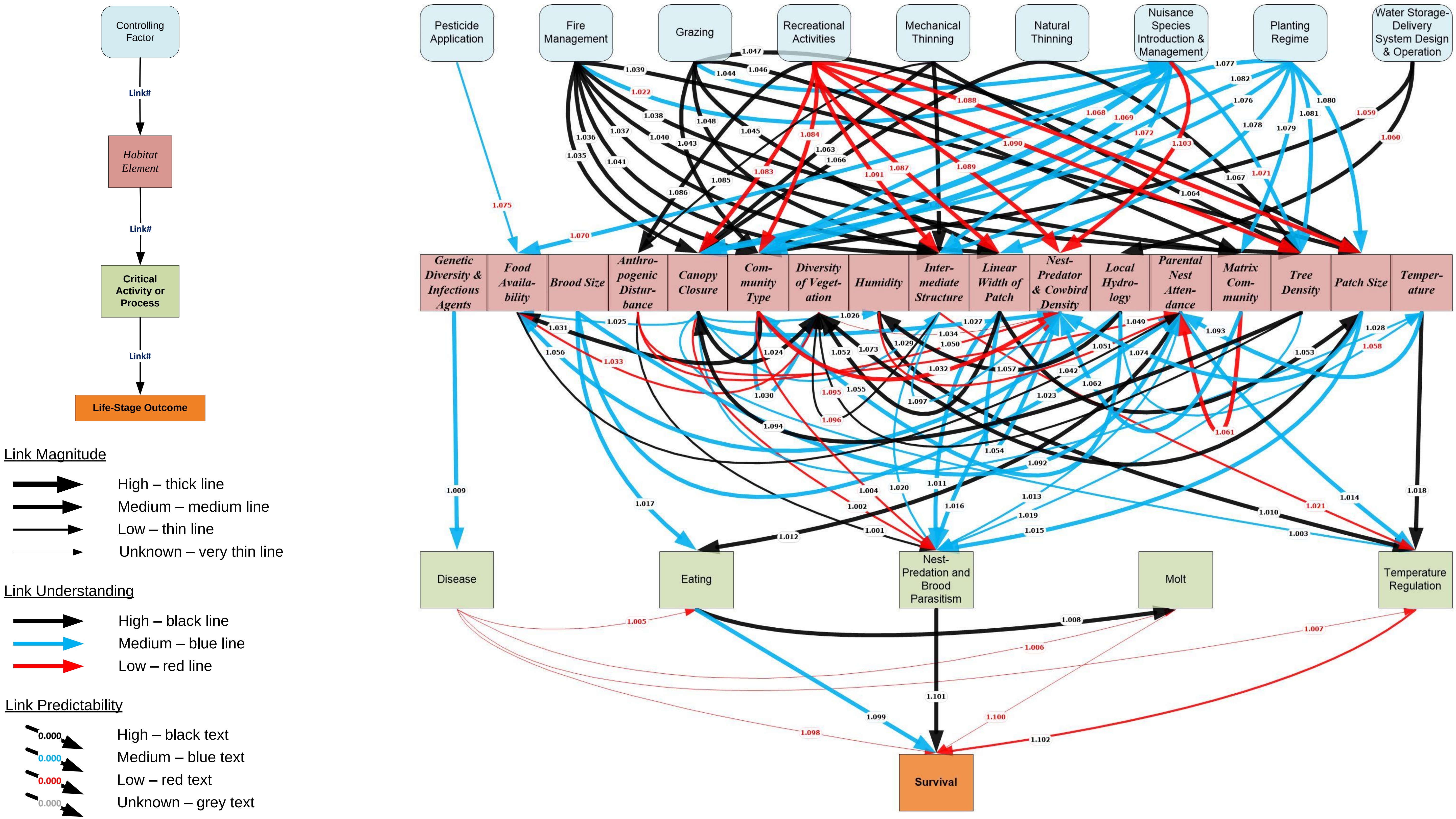


Figure 3.—SWFL life stage 1 – nest, basic CEM diagram.

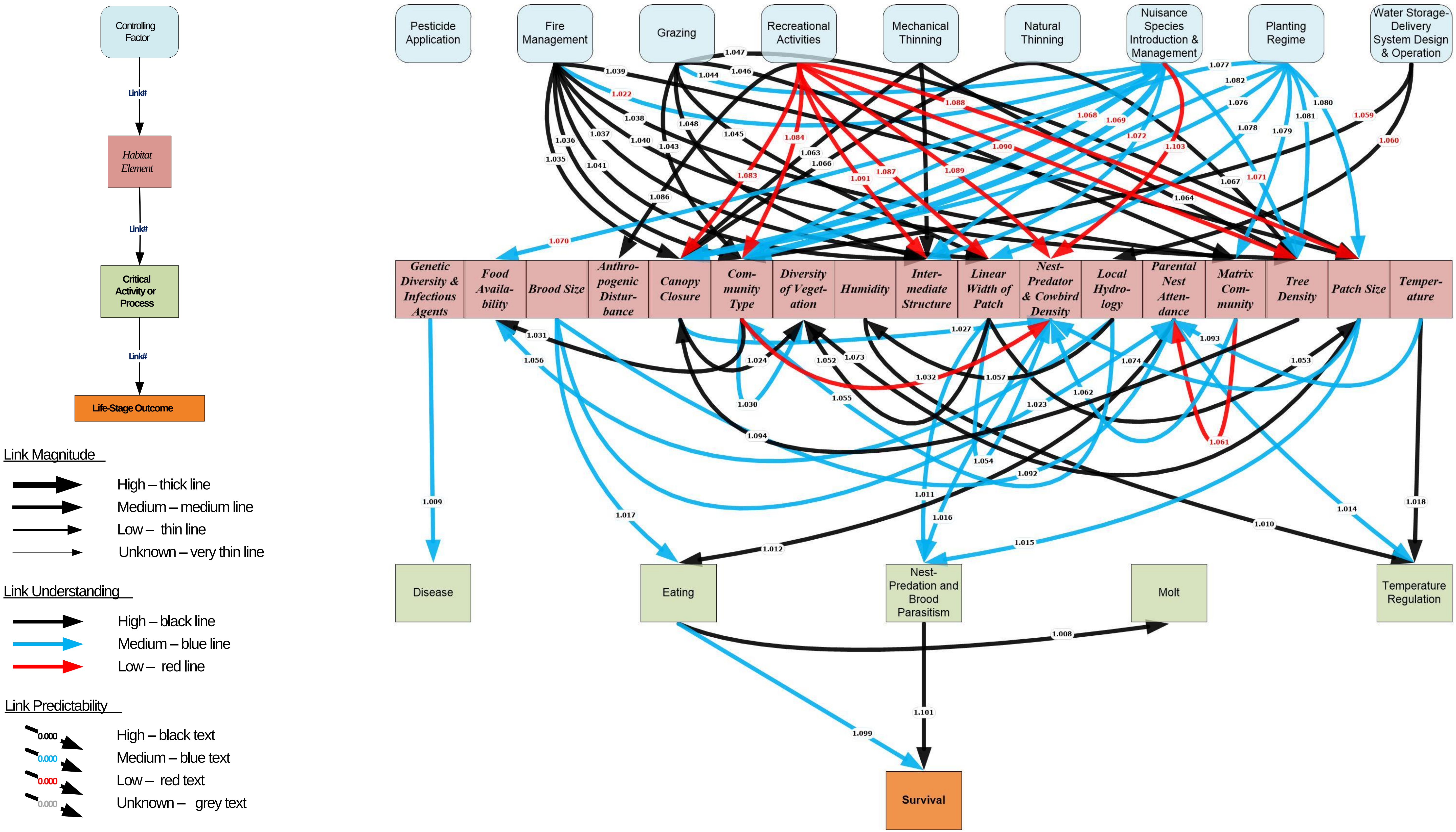


Figure 4.—SWFL life stage 1 – nest, high- and medium-magnitude relationships.

SWFL LIFE STAGE 2 – JUVENILE

The juvenile stage begins at fledging and ends when the bird engages in breeding activities, usually the following year. Success during this life stage – successful transition to the next stage – involves organism survival and maturation. The organisms actively interact with their environment.

The CEM (figures 5 and 6) recognizes four (of nine) critical biological activities and processes for this life stage, ordered here as they appear on the following figures:

1. **Disease** – Although the literature does not emphasize disease as affecting population levels of SWFL, we still feel that disease bears mentioning, and it has been recommended as an area for further research (Paxton et al. 2007).

   The CEM recognizes genetic diversity and infectious agents as a habitat element affecting disease.

2. **Foraging** – Although still fed by its parents, the juvenile can now also forage for its own food in order to eat and maintain metabolic processes. The degree to which it is dependent upon foraging relates to the feeding rate of the parents and all of the factors affecting parent survival.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, diversity of vegetation, food availability, matrix community, and parental feeding behavior as habitat elements affecting foraging. Predator density affects foraging indirectly via predation, but nothing is known about rates for juveniles. In addition, disease can also affect the foraging efficiency of a juvenile, but it is not known to what extent.

3. **Predation** – Brood parasitism is no longer a threat to the survival of SWFL; therefore, it is no longer included with predation.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, intermediate structure, linear width of patch, parental feeding behavior, patch size, predator density, and tree density as habitat elements affecting predation.

4. **Temperature Regulation** – The juvenile must maintain an optimum temperature to survive.

   The CEM recognizes canopy closure, humidity, intermediate structure, and temperature as habitat elements directly affecting temperature regulation.

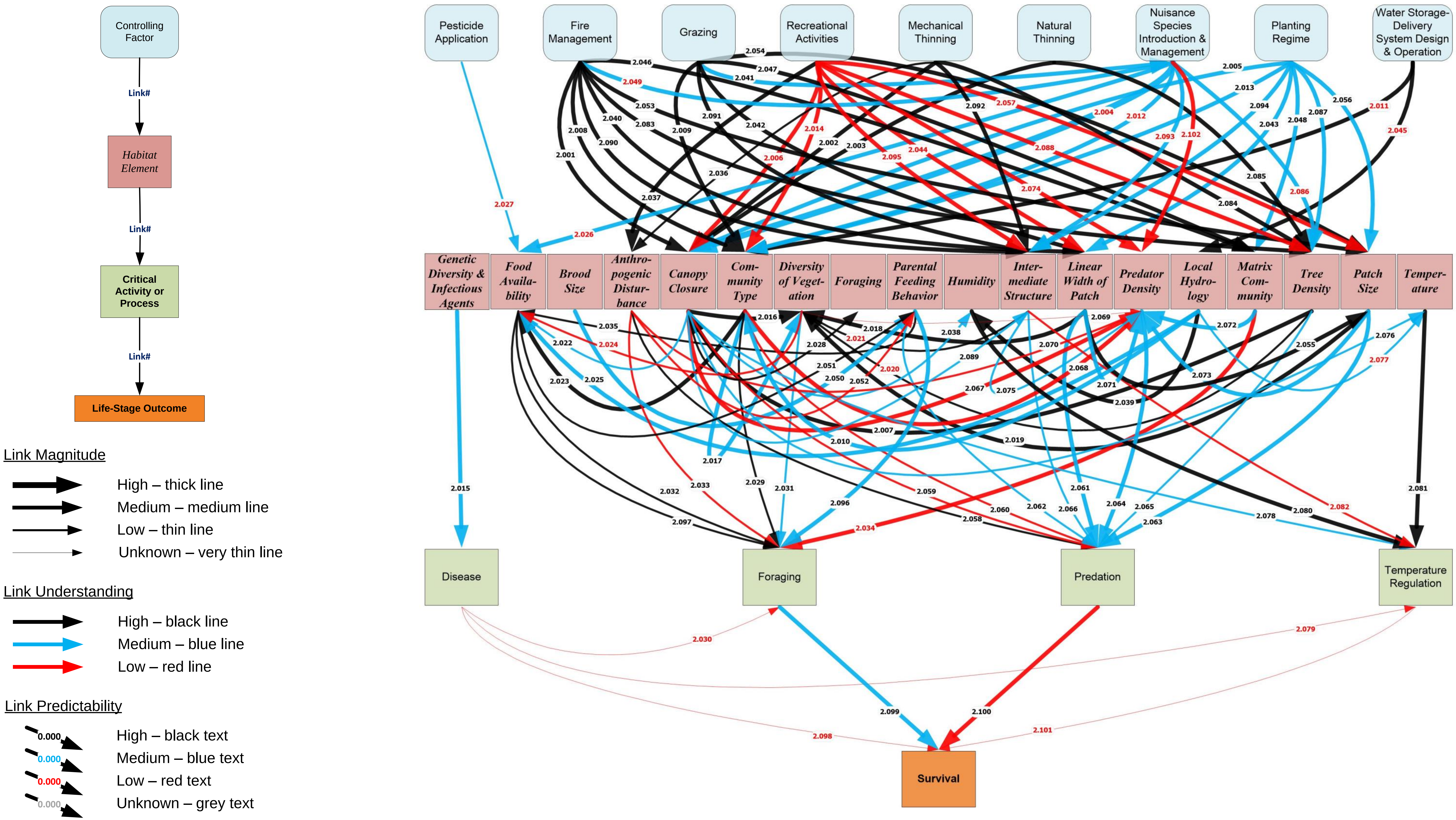


Figure 5.—SWFL life stage 2 – juvenile, basic CEM diagram. Only elements with connections within this life stage are presented.

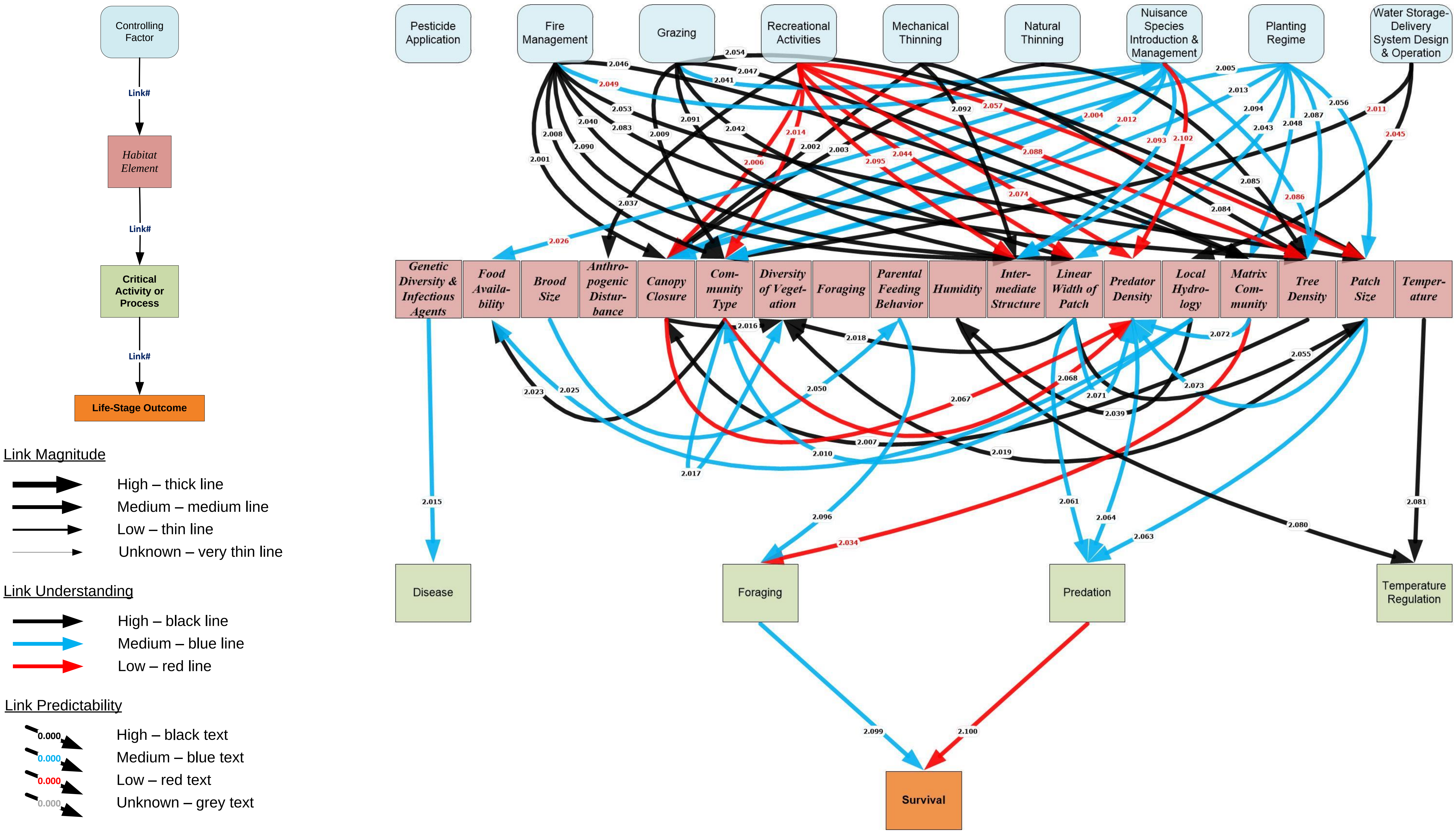


Figure 6.—SWFL life stage 2 – juvenile, high- and medium-magnitude relationships.

SWFL LIFE STAGE 3 – BREEDING ADULT

The breeding adult stage begins when the bird returns to the breeding grounds after its first or subsequent winter and ends when it departs the breeding grounds during fall migration. Success during this life stage – successful transition to the next stage – involves organism survival and breeding. Individuals that do not successfully find a territory, floaters, are also included in this category even though they do not breed. The organisms actively interact with their environment.

The CEM (figures 7 and 8) recognizes six (of nine) critical biological activities and processes for this life stage, ordered here as they appear on the following figures:

1. **Disease** – Although the literature does not emphasize disease as affecting population levels of SWFL, we still feel that disease bears mentioning, and it has been recommended as an area for further research (Paxton et al. 2007).

   The CEM recognizes genetic diversity and infectious agents as a habitat element affecting disease.

2. **Foraging** – The breeding adult must forage to feed itself and its young.

   The CEM recognizes anthropogenic disturbance, brood size, canopy closure, community type, diversity of vegetation, food availability, and the matrix community as affecting foraging.

3. **Predation** – Adults must avoid predation to survive.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, intermediate structure, linear width of patch, patch size, predator density, and tree density as habitat elements affecting predation.

4. **Nest Attendance** – The breeding adult must attend to the nest to incubate eggs, brood young, and feed young.

   The CEM recognizes anthropogenic disturbance, brood size, humidity, predator density, and temperature as habitat elements affecting nest attendance.

5. **Nest Site Selection** – This process includes both territory establishment and the placement of nests. Territory establishment is especially important because if a bird fails to establish a territory (or find a male with a territory in the case of females), the bird will be a floater and is unlikely to breed during that season. The breeding adult must choose where to place territories and nests, thereby affecting breeding success.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, conspecific attraction, distance to occupied patch, diversity of vegetation, humidity, intermediate structure, linear width of patch, matrix community, patch size, predator density, previous year's use, temperature, and tree density as habitat elements affecting nest site selection.

6. **Temperature Regulation** – The adult must maintain an optimum temperature to survive.

   The CEM recognizes canopy closure, humidity, intermediate structure, and temperature as habitat elements directly affecting temperature regulation.

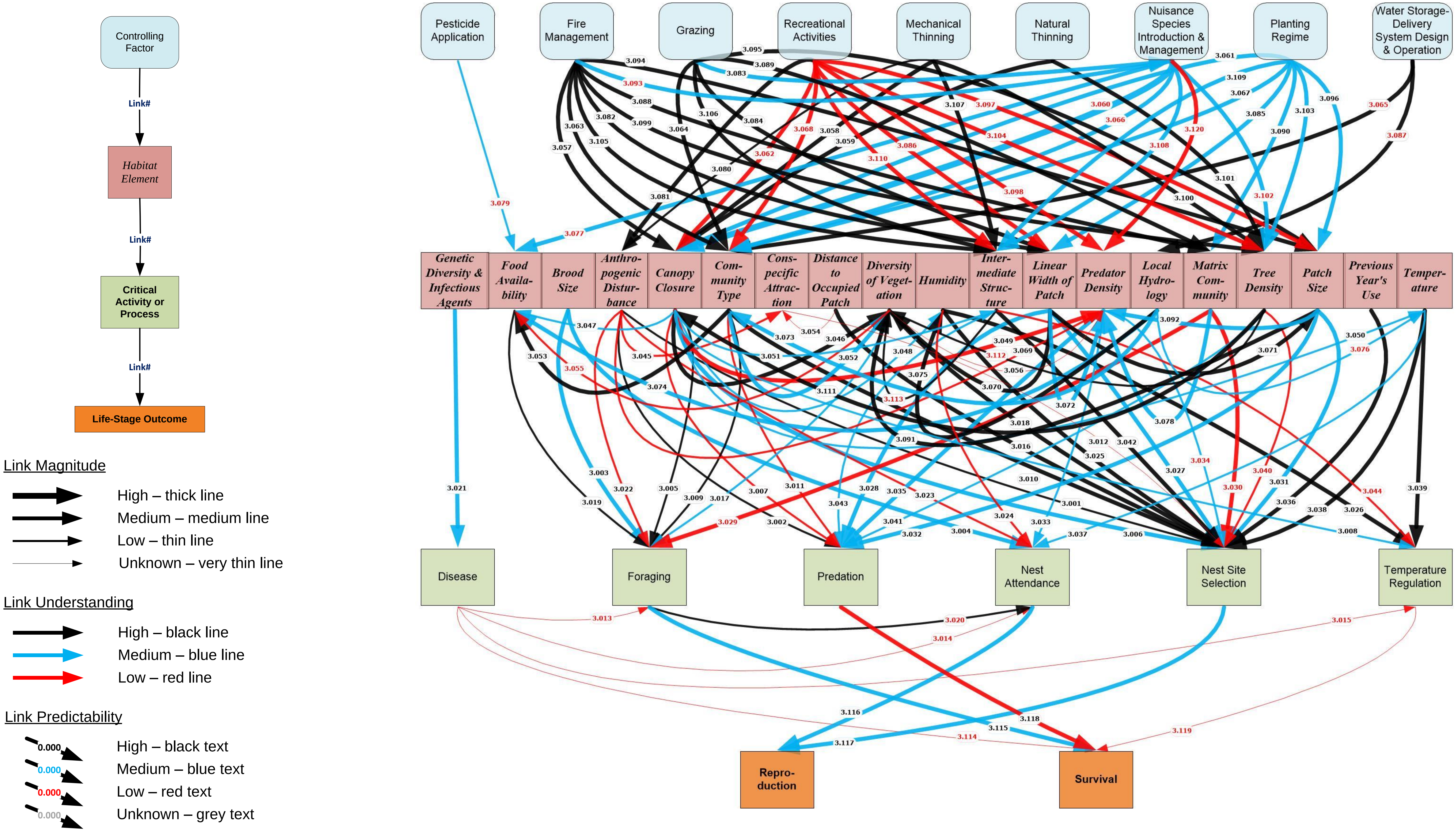


Figure 7.—SWFL life stage 3 – breeding adult, basic CEM diagram.

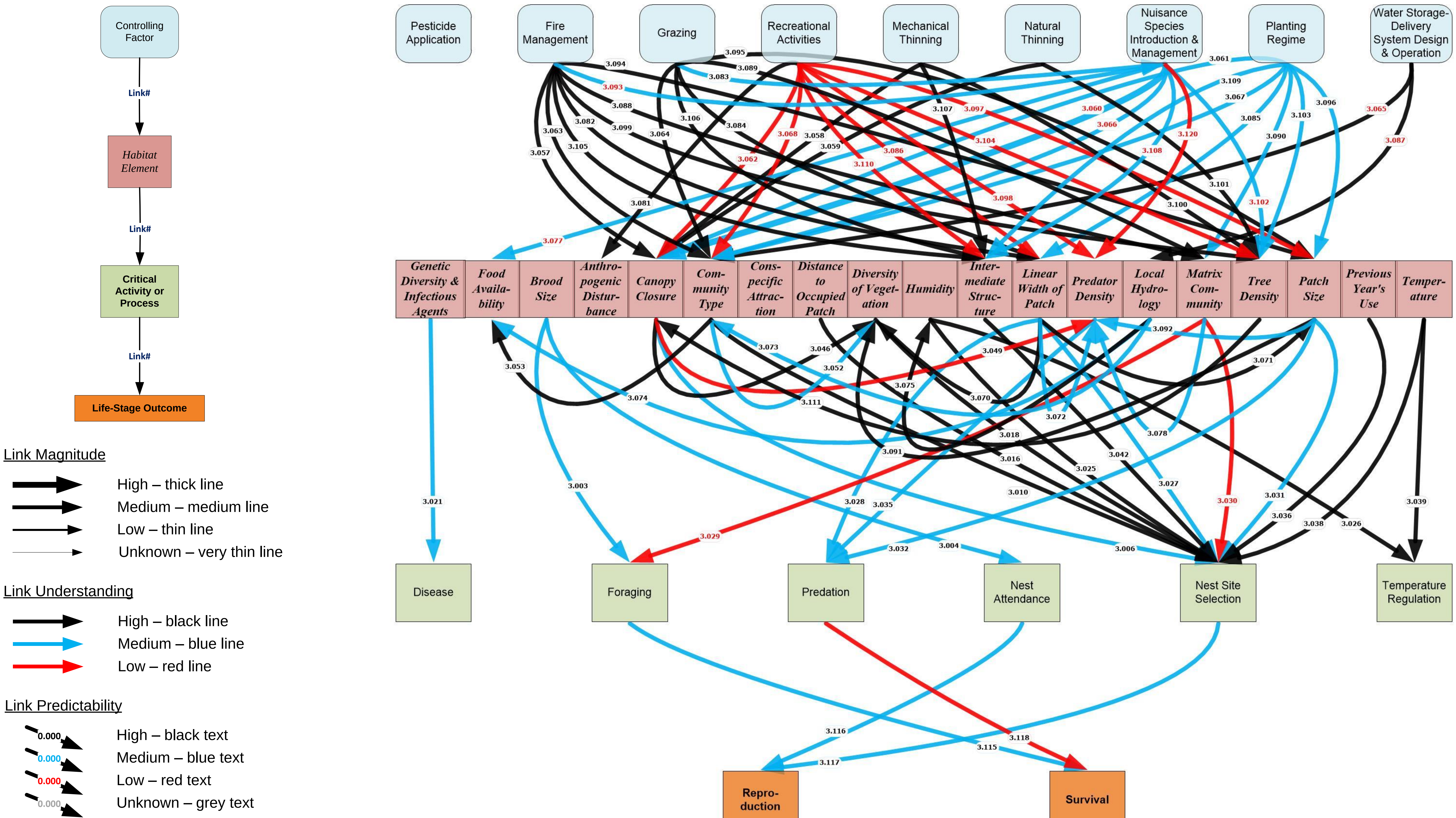


Figure 8.—SWFL life stage 3 – breeding adult, high- and medium-magnitude relationships.

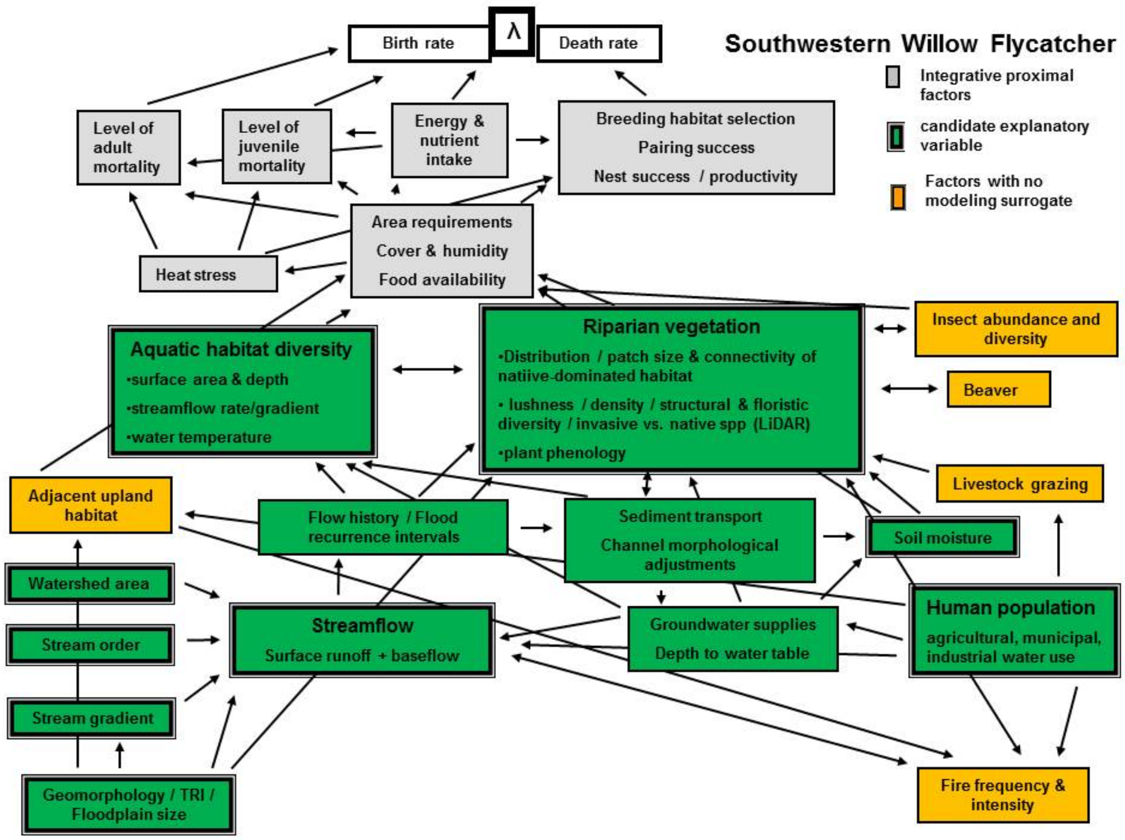


Figure F-1. Southwestern willow flycatcher conceptual model of factors that might possibly affect flycatcher and population dynamics that includes changing physiological and environmental integrative proximal factors (gray), candidate explanatory variables (green) and factors with no modeling surrogate (orange) that may affect flycatcher productivity but have no direct data to support it.

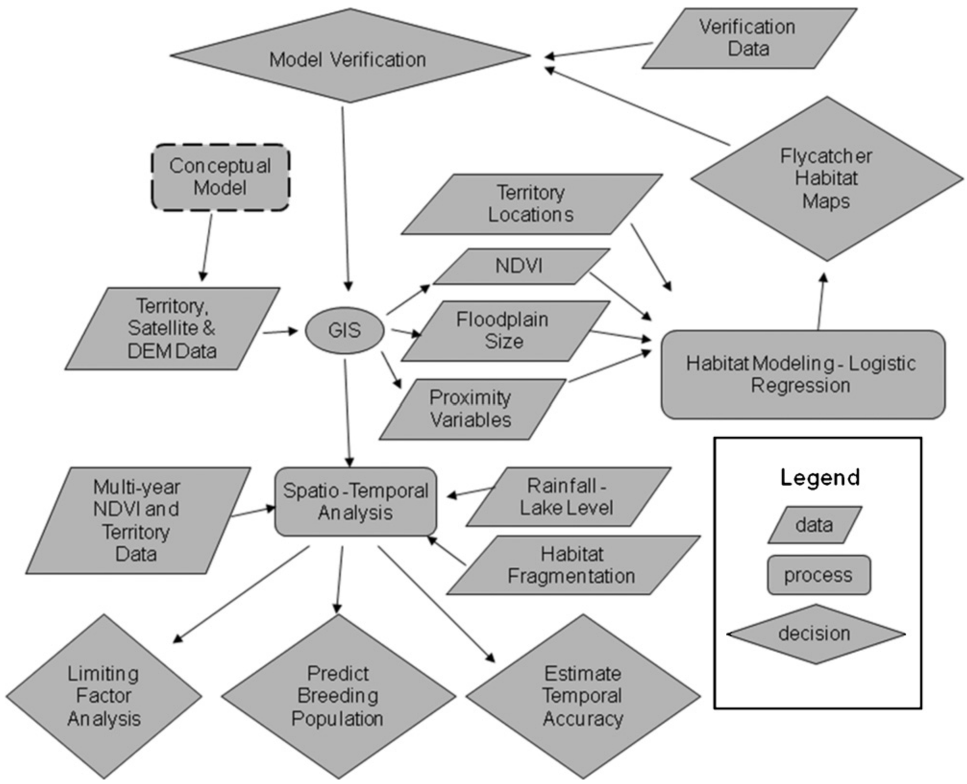


Fig. 2. A flowchart depicts the steps and processes we undertook to create and test a spatial model of Southwestern Willow Flycatcher breeding habitat at Roosevelt Lake, examine factors that limit formation of habitat, and to estimate the flycatcher breeding population.

Fig. 3. A conceptual diagram of Southwestern Willow Flycatcher breeding habitat. Habitat features thought to be important included size of floodplain, distance to water, density and heterogeneity in riparian vegetation, vegetation seral stage, and size and shape of vegetation patches.

YBCU LIFE STAGE 1 – NEST

The nest stage lasts from when the egg is laid until either the young fledge or the nest fails. Success during this life stage – successful transition to the juvenile stage – involves organism survival, maturation, molt, and fledging. The organisms actively interact with their environment.

The CEM (figures 3 and 4) recognizes five (of eight) critical biological activities and processes for this life stage. Not included are foraging, nest attendance, and nest site selection, as they are not part of the nest life stage. The critical biological processes and activities are presented here, ordered as they appear on the following figures.

1. **Disease** – Although the literature does not emphasize disease as affecting population levels of YBCU, we still feel that disease bears mentioning. Diseases and parasites are prevalent in avian populations, so it is safe to assume they have an impact on YBCU (Morishita et al. 1999). Disease and parasite impacts along the LCR is recommended as an area of potential research.

   The CEM recognizes genetic diversity and infectious agents as a habitat element affecting disease.

2. **Eating** – The nestling must eat to maintain metabolic processes.

   The CEM recognizes disease as the critical biological activity and process affecting eating, as does the habitat element of parental nest attendance.

3. **Predation** – Predation affects the survival of a nest.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, diversity of vegetation, intermediate structure, linear width of patch, parental nest attendance, patch size, predator density, and tree density as habitat elements affecting nest predation.

4. **Temperature Regulation** – The eggs and nestlings must maintain an optimum temperature to develop and survive.

   The CEM recognizes canopy closure, humidity, intermediate structure, parental nest attendance, and temperature as primary habitat elements directly affecting temperature regulation. The only critical biological activity and process having a direct impact on temperature regulation is disease.

5. **Molt** – The nestling must molt into juvenile plumage.

   The CEM recognizes the critical biological activities and processes of disease and eating as influencing molt. The CEM does not recognize any habitat elements as directly affecting molt.

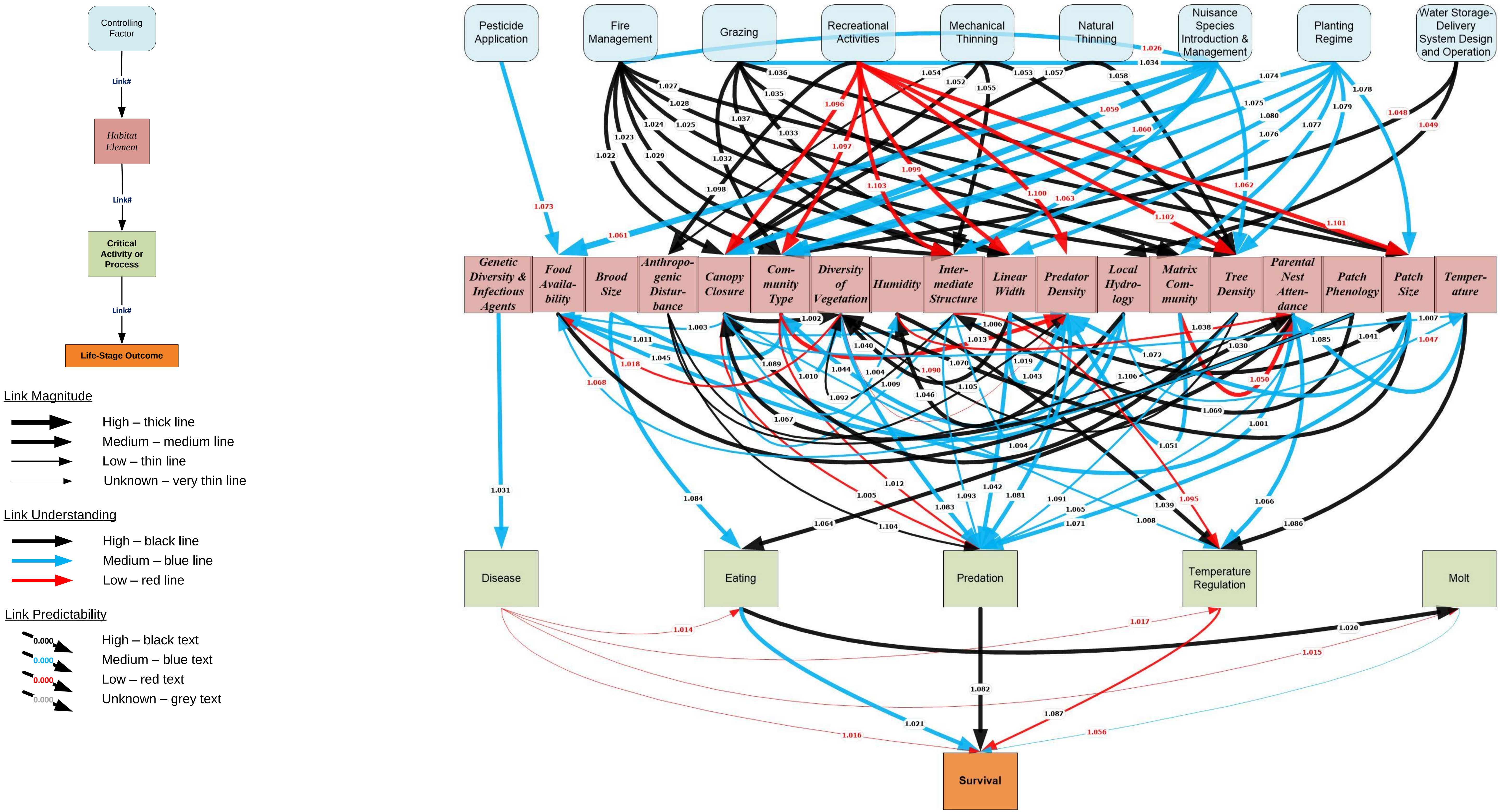


Figure 3.—YBCU life stage 1 – nest, basic CEM diagram showing the relevant controlling factors, habitat elements, and critical biological activities and processes at this life stage.

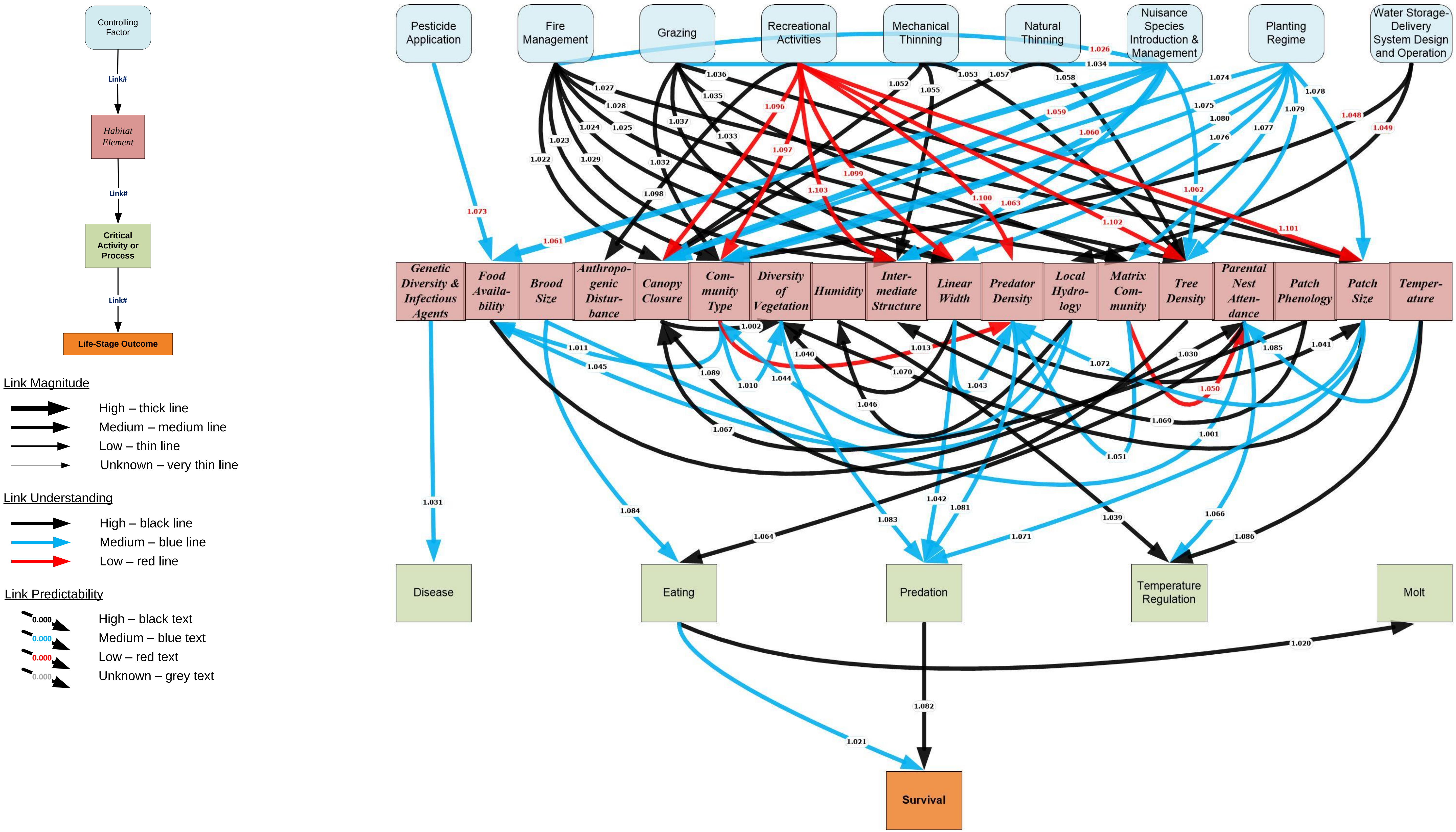


Figure 4.—YBCU life stage 1 – nest, high- and medium-magnitude relationships showing the relevant controlling factors, habitat elements, and critical biological activities and processes at this life stage.

YBCU LIFE STAGE 2 – JUVENILE

The juvenile stage begins at fledging and ends when the bird returns to the breeding grounds the next year. However, for the sake of this analysis, we will only emphasize the period between fledging and departure during autumn migration.

Success during this life stage – successful transition to the next stage – involves organism survival and maturation. The organisms actively interact with their environment.

The CEM (figures 5 and 6) recognizes five (of eight) critical biological activities and processes for this life stage. Eating, nest attendance, and nest site selection are not included, as they are part of other life stages. The critical biological processes and activities are presented here, ordered as they appear on the following figures.

1. **Disease** – Although the literature does not emphasize disease as affecting population levels of YBCU, we still feel that disease bears mentioning. Diseases and parasites are prevalent in avian populations, so it is safe to assume they have an impact on YBCU (Morishita et al. 1999). Disease and parasite impacts along the LCR is recommended as an area of potential research.

   The CEM recognizes genetic diversity and infectious agents as a habitat element affecting disease.

2. **Foraging** – Although still fed by the adult parents, the juvenile can now also forage for its own food in order to eat and maintain metabolic processes.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, diversity of vegetation, food availability, parental feeding behavior, the matrix community, and patch phenology as habitat elements affecting foraging. Foraging is directly affected by the critical biological activity and process of disease.

3. **Predation** – Predation directly affects survival.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, intermediate structure, linear width of patch, parental feeding behavior, patch size, predator density, and tree density as habitat elements directly affecting predation rates.

4. **Temperature Regulation** – The juvenile must maintain an optimum temperature to survive.

   The CEM recognizes canopy closure, humidity, intermediate structure, and temperature as habitat elements directly affecting temperature regulation. Disease as a critical biological activity and process can have influences on temperature regulation.

5. **Molt** – The juvenile must molt into basic plumage, and the process begins on the breeding grounds. Molt affects survival.

   The CEM does not recognize any habitat elements as directly affecting molt but many do indirectly through their impacts on foraging and eating.

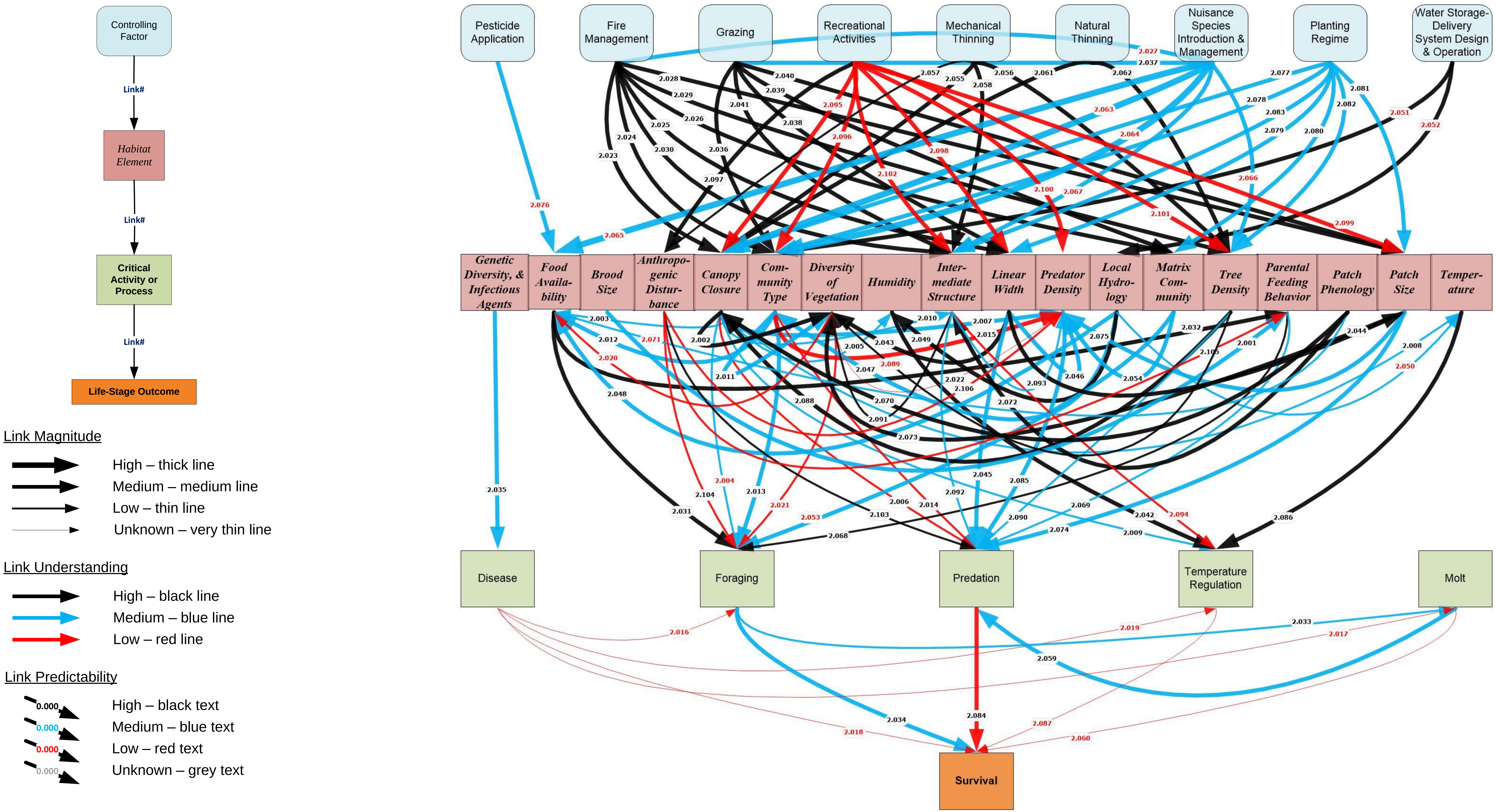


Figure 5.—YBCU life stage 2 – juvenile, basic CEM diagram showing the relevant controlling factors, habitat elements, and critical biological activities and processes at this life stage.

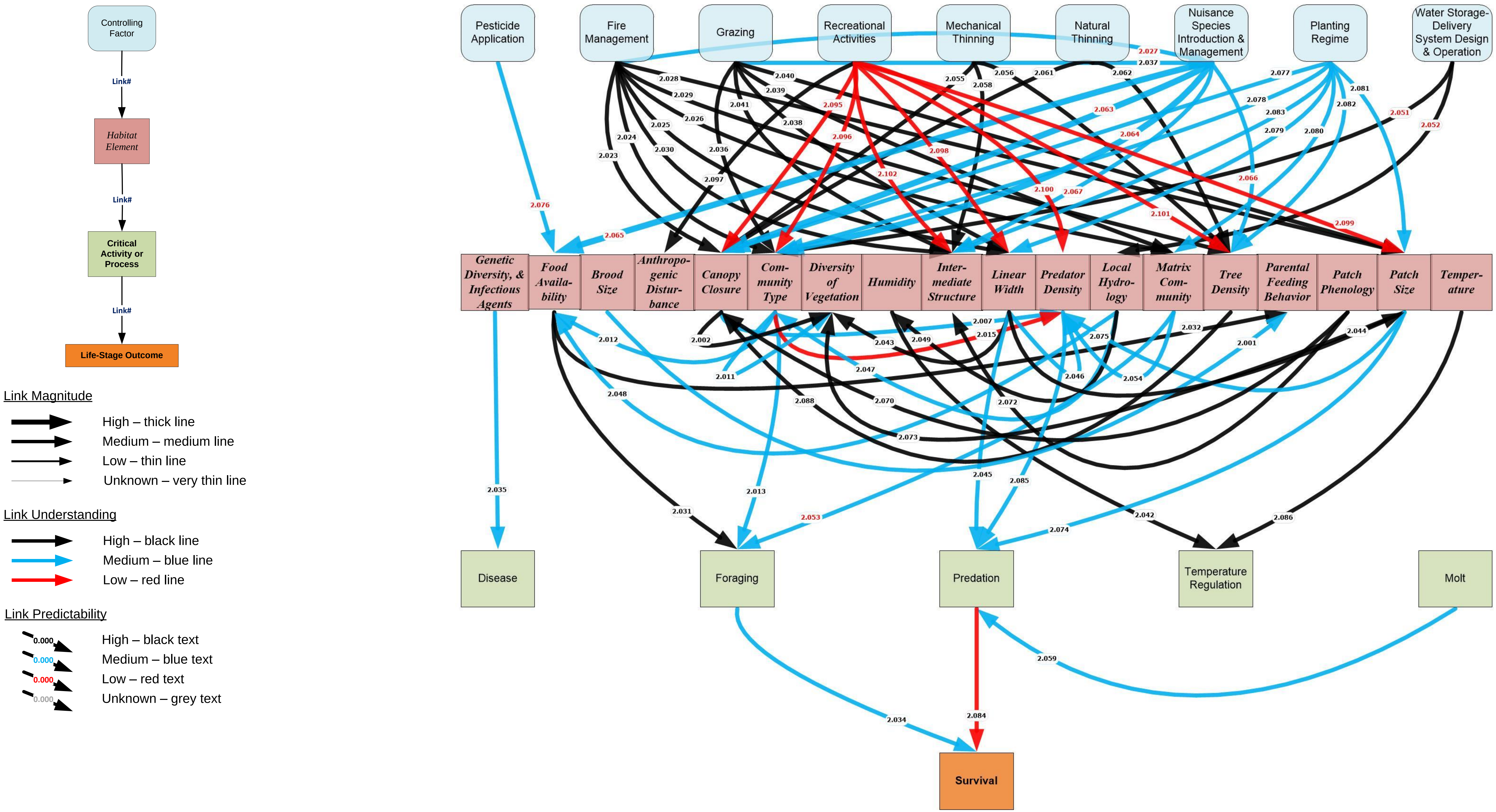


Figure 6.—YBCU life stage 2 – juvenile, high- and medium-magnitude relationships showing the relevant controlling factors, habitat elements, and critical biological activities and processes at this life stage.

YBCU Life Stage 3 – Breeding Adult

The breeding adult stage begins when the bird returns to the breeding grounds after its first or subsequent winter and ends when it departs the breeding grounds during fall migration. Success during this life stage – successful transition to the next stage – involves organism survival and breeding. Individuals that do not successfully find a territory, floaters, are also included in this category even though they do not breed. The organisms actively interact with their environment.

The CEM (figures 7 and 8) recognizes seven (of eight) critical biological activities and processes for this life stage. Eating is not included as it is part of the nest life stage. The critical biological processes and activities are presented here, ordered as they appear on the following figures.

1. **Disease** – Although the literature does not emphasize disease as affecting population levels of YBCU, we still feel that disease bears mentioning. Diseases and parasites are prevalent in avian populations, so it is safe to assume they have an impact on YBCU (Morishita et al. 1999). Disease and parasite impacts along the LCR is recommended as an area of potential research.

   The CEM recognizes genetic diversity and infectious agents as a habitat element affecting disease.

2. **Foraging** – The breeding adult must forage to feed itself and its young. Both their survival and their young are dependent upon the foraging rate, which can be influenced by a number of factors.

   The CEM recognizes anthropogenic disturbance, brood size, canopy closure, community type, diversity of vegetation, food availability, the matrix community, and patch phenology as habitat elements directly affecting foraging. Disease is a critical biological activity and process that also directly affects foraging.

3. **Predation** – Adults must avoid predation to survive.

   The CEM recognizes anthropogenic disturbance, canopy cover, community type, linear width of patch, patch size, predator density, and tree density as habitat elements affecting predation. There are no critical biological activities and processes that directly affect predation.

4. **Nest Site Selection** – The breeding adult must choose where to place the nest, as nest placement will affect breeding success.

   The CEM recognizes anthropogenic disturbance, canopy closure, community type, diversity of vegetation, humidity, intermediate structure, linear width of patch, the matrix community, patch phenology, patch size, predator density, temperature, and tree density as habitat elements affecting nest site selection. There are no critical biological activities and processes that directly affect nest site selection.

5. **Nest Attendance** – The breeding adult must attend the nest to incubate eggs, brood young, and feed young.

   The CEM recognizes anthropogenic disturbance, brood size, humidity, predator density, and temperature as habitat elements affecting nest attendance. Disease and foraging are the critical biological activities and processes that directly affect nest attendance.

6. **Temperature Regulation** – The adult must maintain an optimum temperature to survive.

   The CEM recognizes humidity and temperature as well as canopy closure and intermediate structure as primary habitat elements affecting temperature regulation. The critical biological activity and process of disease directly affects temperature regulation.

7. **Molt** – The adult must undergo a post-nuptual molt, and the process begins on the breeding grounds. This activity takes resources that must be directed from other biological processes. Molt requires food (through foraging) and is impacted by disease.

   The CEM does not recognize any habitat variables as directly affecting molt.

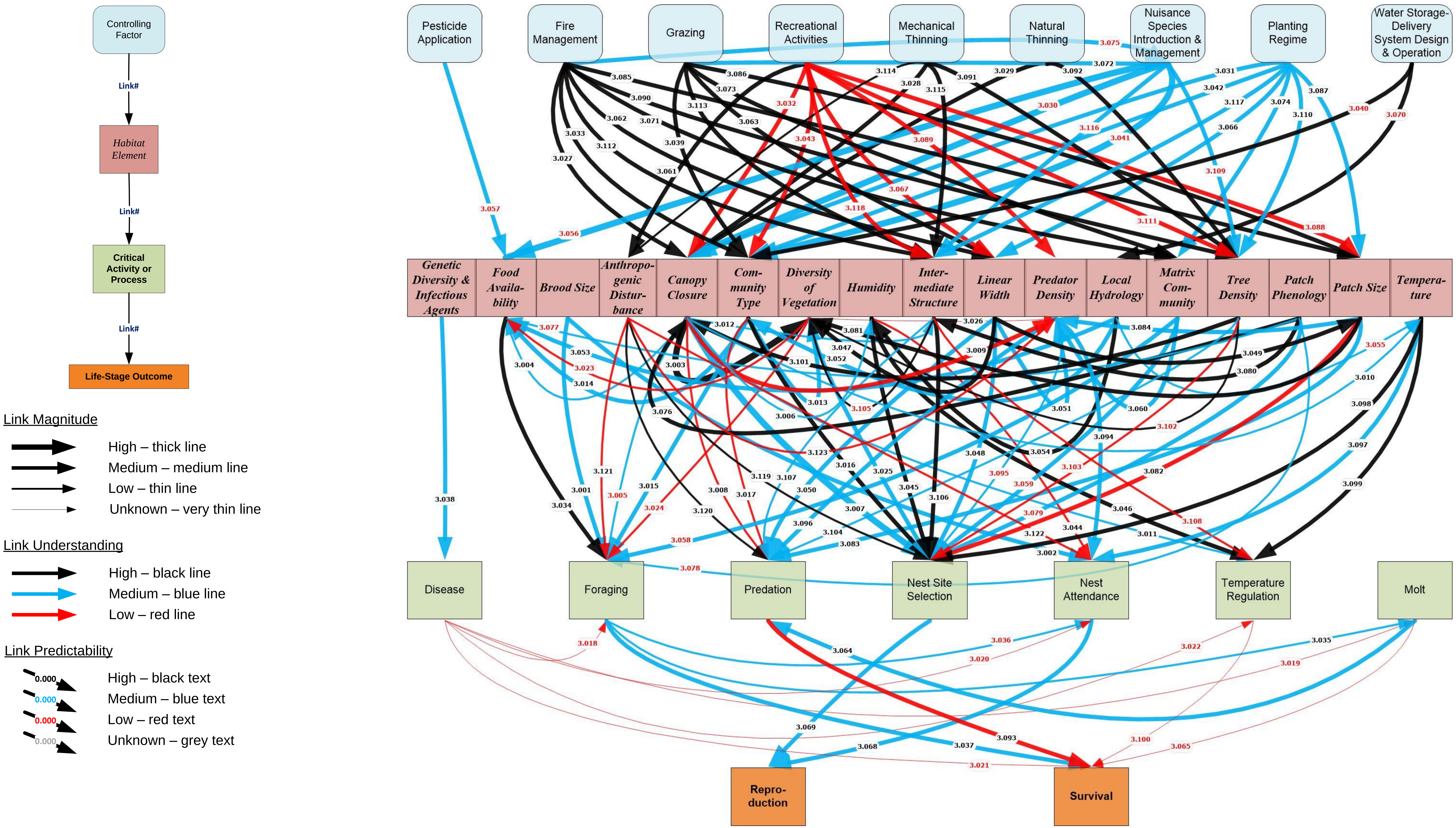


Figure 7.—YBCU life stage 3 – breeding adult, basic CEM diagram showing the relevant controlling factors, habitat elements, and critical biological activities and processes at this life stage.

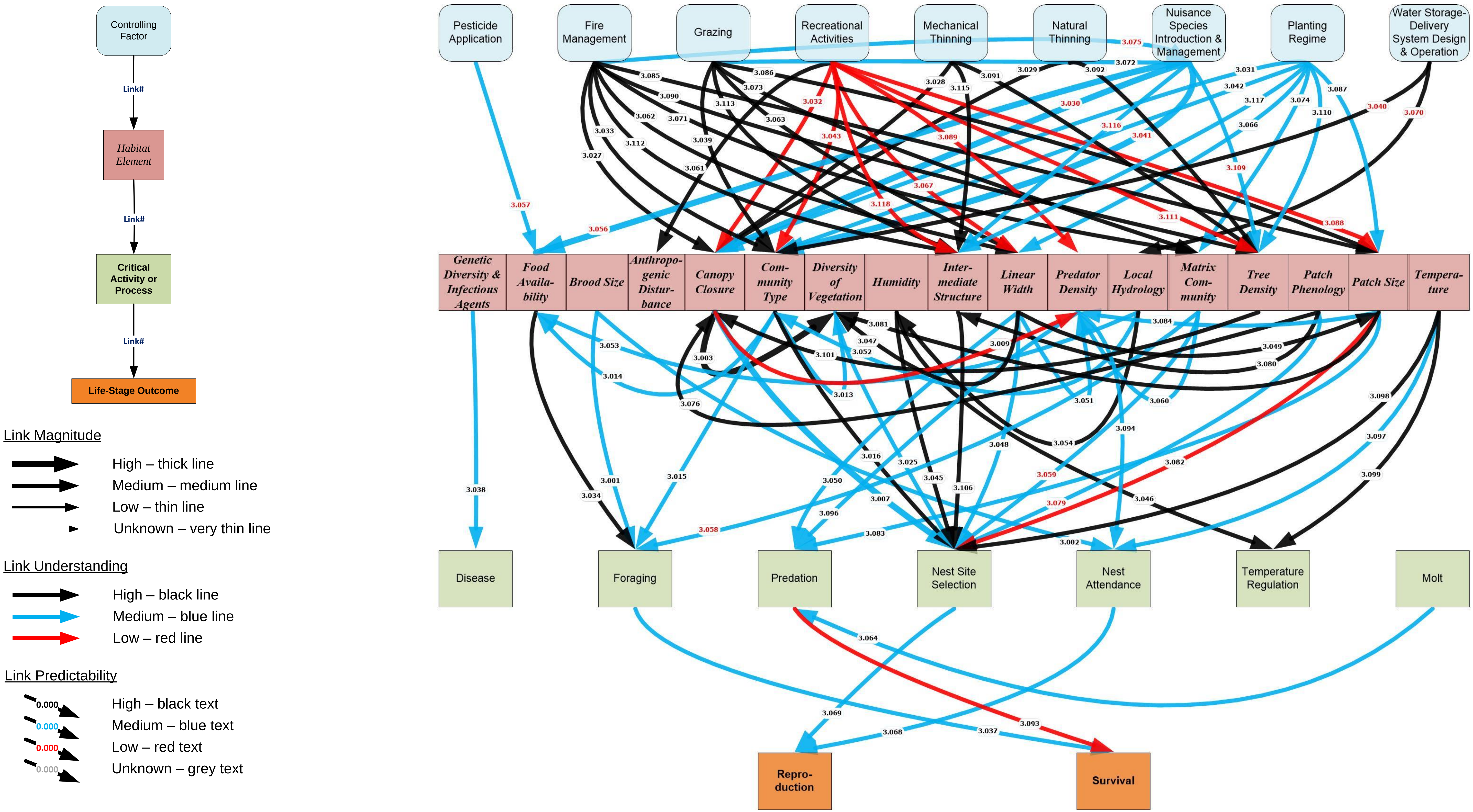


Figure 8.—YBCU life stage 3 – breeding adult, high- and medium-magnitude relationships showing the relevant controlling factors, habitat elements, and critical biological activities and processes at this life stage.