Applying Satellite-based Habitat Models to Inform Riparian Habitat Restoration and Management Actions for Two Listed Riparian Species, the Southwestern Willow Flycatcher and the Yellow-billed Cuckoo

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- Riparian obligate species depend on complex, dynamic riparian ecosystems

- Their conservation requires identification of habitat characteristics and other factors that affect the quality, persistence, and resiliency of riparian habitats at multiple spatial and temporal scales

- **Identifying key habitat features is especially important for the conservation of at-risk species**

- **Including the endangered Southwestern Willow Flycatcher (SWFL; *Empidonax traillii extimus*) and the threatened Yellow-billed Cuckoo (YBCU; *Coccyzus americanus*)**

- **Both are riparian obligates and, sometimes, both species occupy the same riparian patch (their habitats and distribution can sometimes overlap)**

- **In general, SWFL can successfully breed in Tamarisk-dominated riparian habitat unlike the YBCU that breeds more successfully in native habitat.**

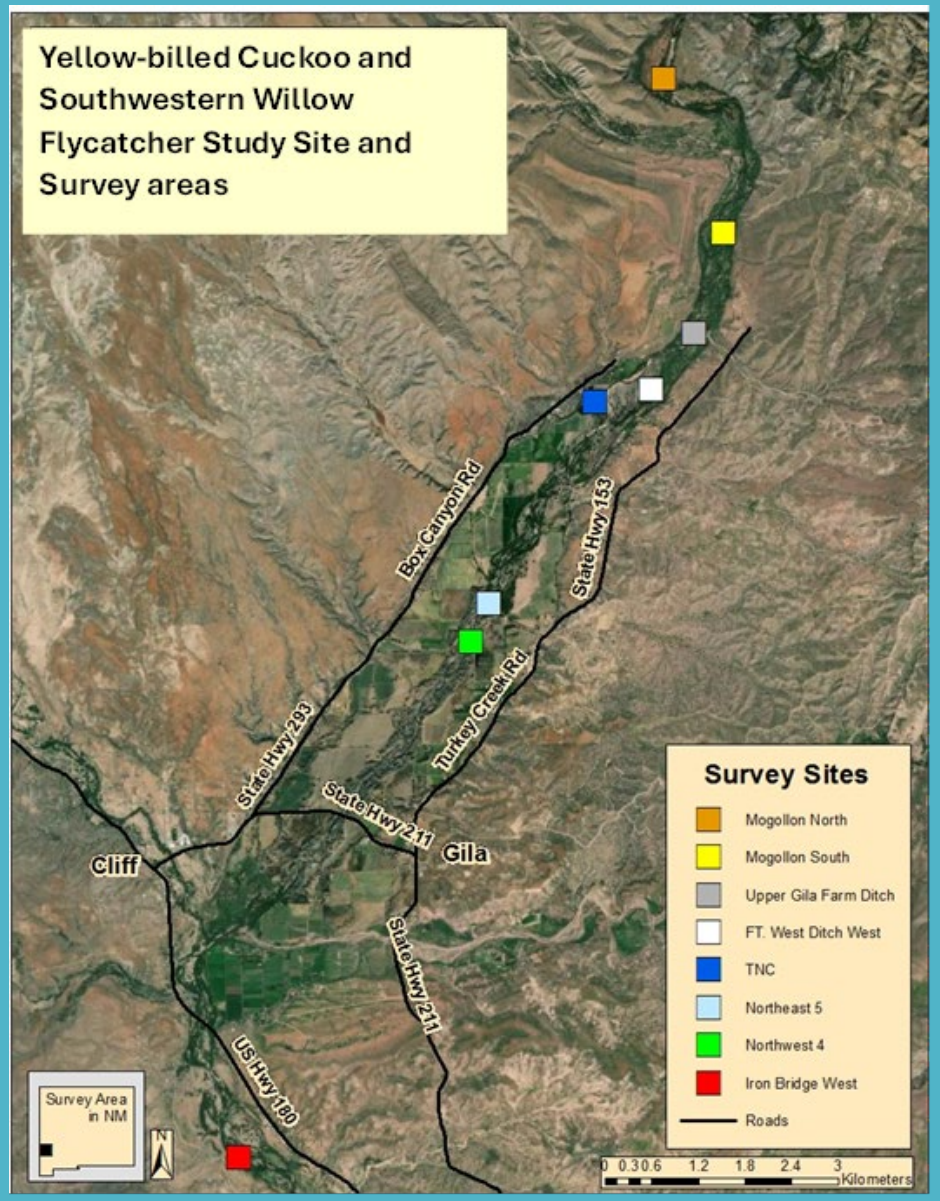
To characterize SWFL and YBCU breeding habitats we examined physical and biological patterns associated with their breeding habitats in two ecologically distinct areas along the Gila River:

- **Native-dominated riparian habitat in the Cliff-Gila Valley, New Mexico**
- **Tamarisk-dominated native mix riparian habitat of the Safford-Gila Valley, Arizona**

Cliff-Gila Valley in New Mexico

- Comprised of native-dominated riparian habitat
- A mosaic of multi-aged riparian forests dominated by numerous native species, wetlands, floodplain grasslands, dry terraces with xeric shrubs and trees, and agriculture
- The Cliff-Gila River flows freely and fluctuates between high and low flows within a year, and across years
- Variable flow patterns create spatial complexity
- Periodic large floods rework the floodplain and support nutrient cycling

Cliff-Gila Valley in New Mexico



- The Cliff-Gila Valley has 8 study sites that we surveyed for **SWFL** and **YBCU** using standardized methods

- The Nature Conservancy owns and manages the sites to conserve healthy riparian habitat for native riparian obligate species, including **SWFL** and **YBCU**

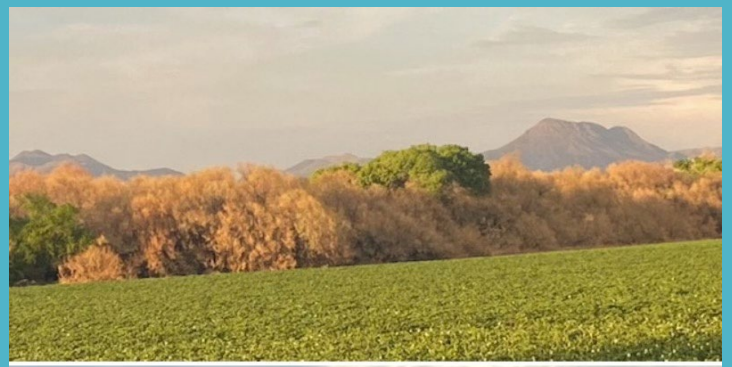
Safford-Gila Valley in Arizona

- Comprised of tamarisk-dominated native-mix riparian habitat

- Riparian habitat borders the river and consists of tamarisk-dominated woodlands with some mesquite and patches of cottonwood forest, within an agricultural landscape

- The Gila River has numerous diversions, primarily for agriculture. It has seasonal flows with peak flows occurring in the winter at times and summer and fall months during monsoons

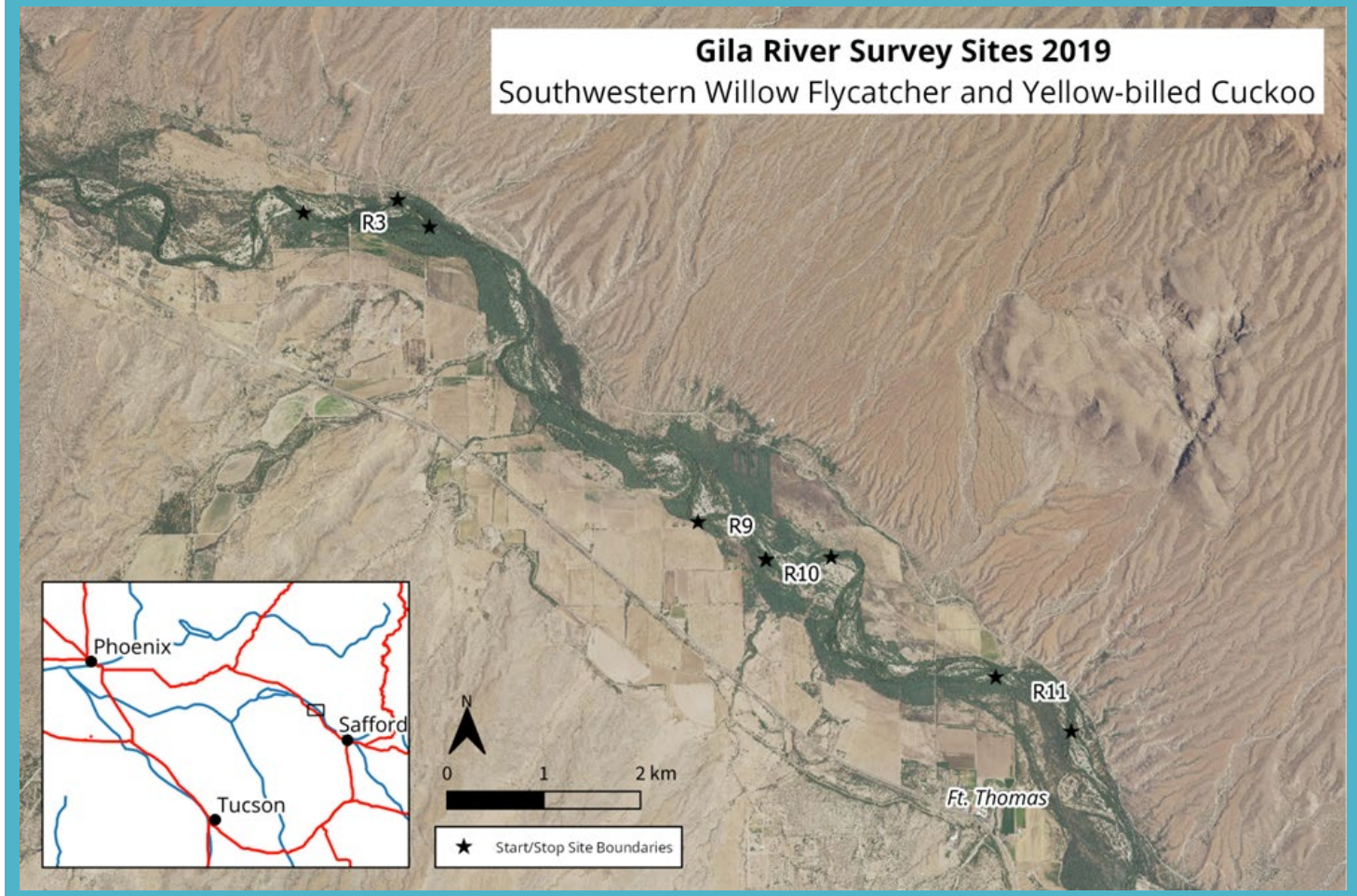
- Tamarisk Beetle arrived at the Gila Box 2020, but didn’t reach our study area until July 2022; by 2023, Tamarisk Beetles were throughout the area and heavily defoliated all study sites



Safford-Gila Valley in Arizona

Within the Safford-Gila Valley we have 6 study sites that we surveyed for **SWFL** and **YBCU** using standardized methods

Private entities own and manage a large percent of the riparian zones in this watershed and have an effect on riparian habitat that impact **SWFLs** and **YBCUs**. (agriculture, water availability, fires, drought and tamarisk beetle).



We assessed key habitat characteristics, dynamics, and persistence of these two habitat types and their relationship to the distribution and abundance of SWFL and YBCU across multiple time and spatial scales

Specifically, we

1) Identified predicted **SWFL** and **YBCU** breeding habitats in the Cliff-Gila and the Safford-Gila Valleys by applying our two published satellite models that characterize riparian vegetation and patch dynamics

2) Assessed the amount of shared/overlapping **SWFL**-**YBCU** habitat within the native-dominated Cliff-Gila, and the tamarisk-dominated Safford-Gila study

3) Used model outputs to create a set of habitat time series (by year) at Valley (landscape) and patch (site) scales to gain insights into multitemporal associations between **SWFL** and **YBCU** distributions and habitat characteristics

4) Examined the relationships between model-predicted **SWFL** and **YBCU** habitats and streamflow to gain insights into its effects on the quality, persistence, and resiliency of riparian habitats and inform management and conservation planning and actions regarding **SWFL** and **YBCU**.

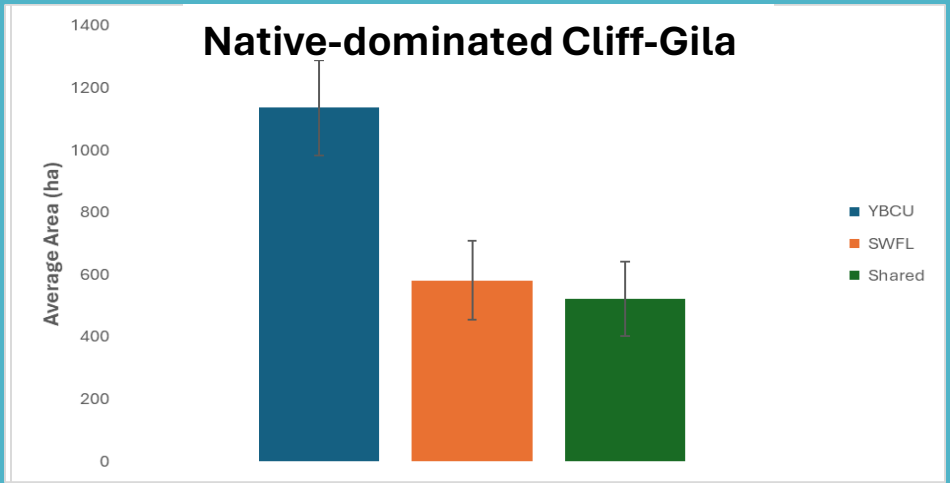
First, we applied our two published satellite-based models of **SWFL** (Hatten and Paradzick 2003) and **YBCU** breeding habitat (Johnson et al. 2017) to the study areas

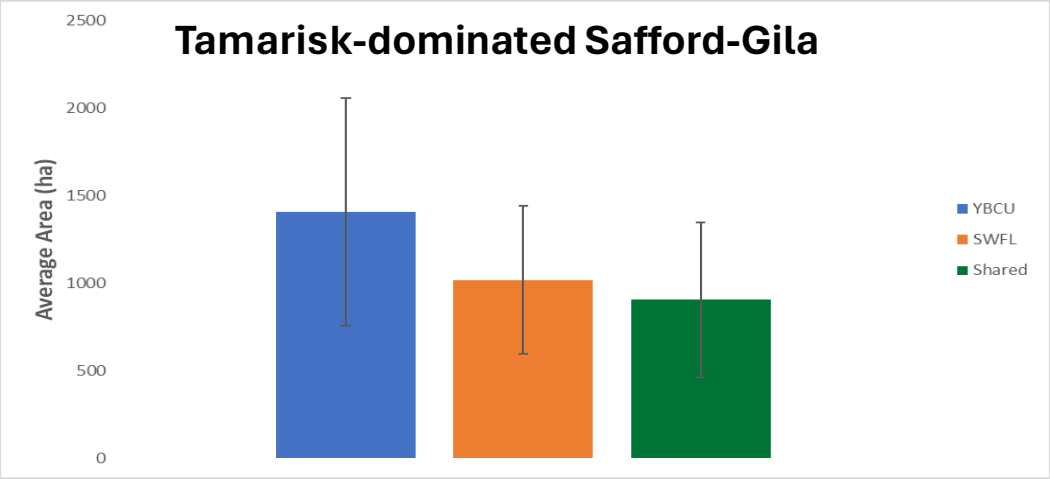
These models were developed with these data:

- **SWFL** and **YBCU** location data from field surveys
- Landsat Thematic Mapper images to measure density and lushness of riparian vegetation with the normalized difference vegetation index (NDVI)
- Digital elevation model to extract floodplain features

- Each model uses a logistic regression equation to divide riparian vegetation into a continuous range of probabilities extending from almost 0 to 99 percent, with higher probabilities most likely to contain a **SWFL** or **YBCU**
- We ran the models annually and produced maps depicting habitat (i.e., areas with a probability above a given threshold of being habitat) for each respective year and species

Then, we assessed the amount of shared/overlapping SWFL-YBCU habitat within the native-dominated Cliff-Gila, and the tamarisk-dominated Safford-Gila study





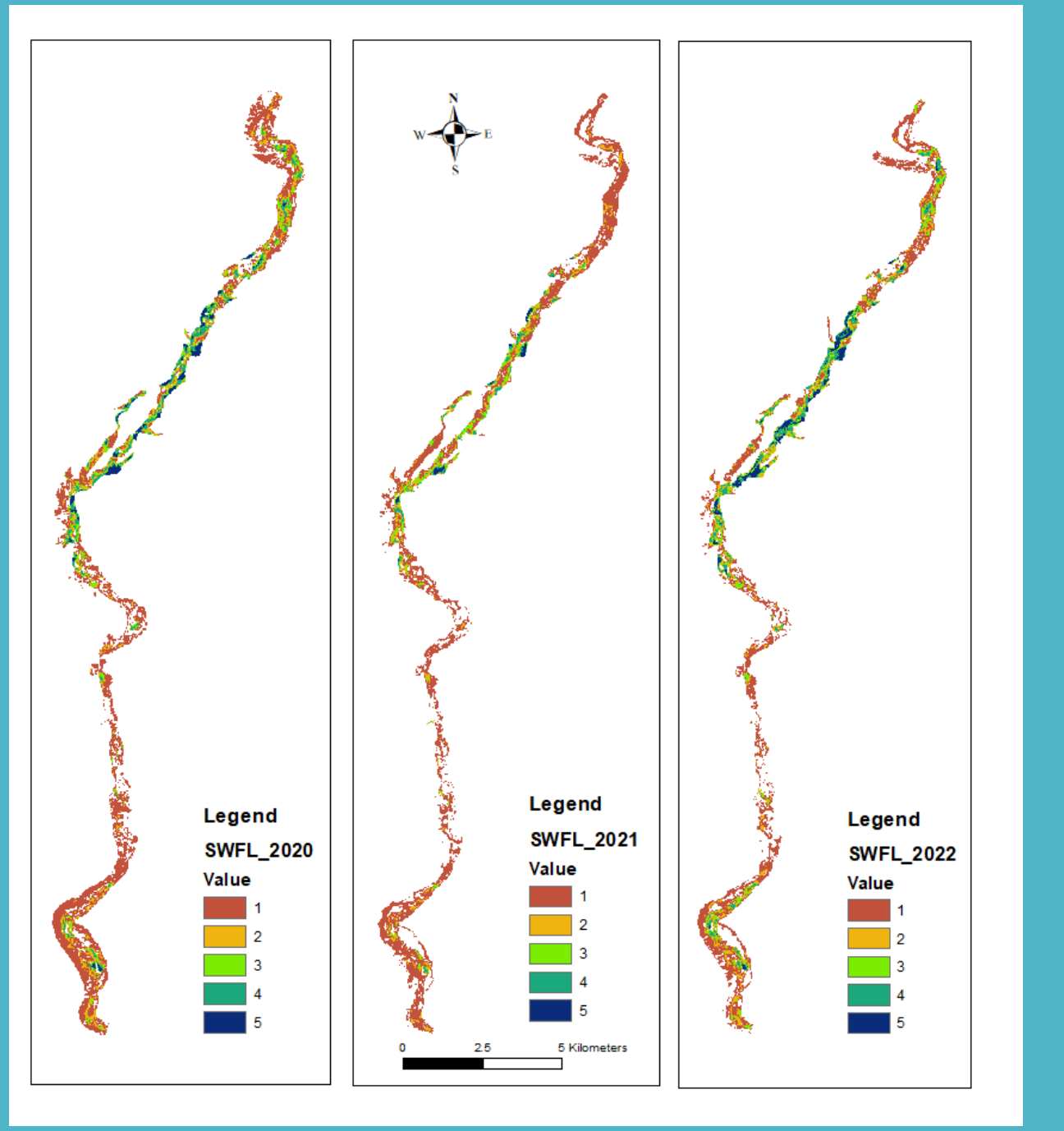
Average area of predicted habitat per year (2013 through 2023) for **SWFL**, **YBCU**, and **SWFL-YBCU** (shared) habitat. Error bars depict ± one standard deviation.

- Cliff-Gila **YBCU** had, on average, almost twice (1.95%) as much predicated habitat as **SWFL**
- On average, approximately 46% of predicted **YBCU** habitat was also predicted **SWFL** habitat.
- In contrast, approximately 90% of predicted **SWFL** habitat overlapped, or was shared with, predicted **YBCU** habitat

- Safford-Gila **YBCU** had, on average, about 1/3 (1.38%) more predicated habitat than **SWFL**
- On average, approximately 64% of predicted **YBCU** habitat was also predicted **SWFL** habitat.
- In contrast, approximately 88% of predicted **SWFL** habitat overlapped, or was shared with, predicted **YBCU** habitat

To assess changes in predicted **SWFL** and **YBCU** habitat over time in the Cliff-Gila and Safford Valleys, we created habitat time series at two spatial scales: the entire study area, and each study site, from 2013 to 2023

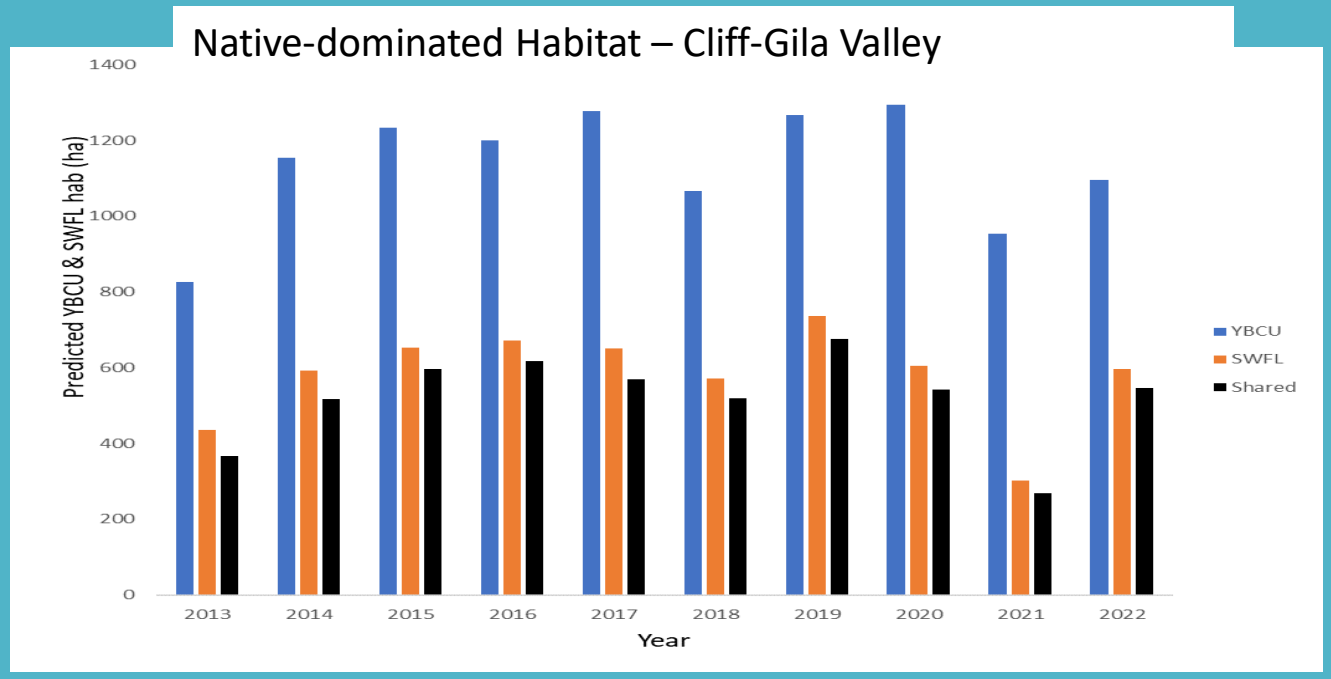
Example of model-generated SWFL habitat map for the Cliff-Gila in the consecutive years (2020-2022)

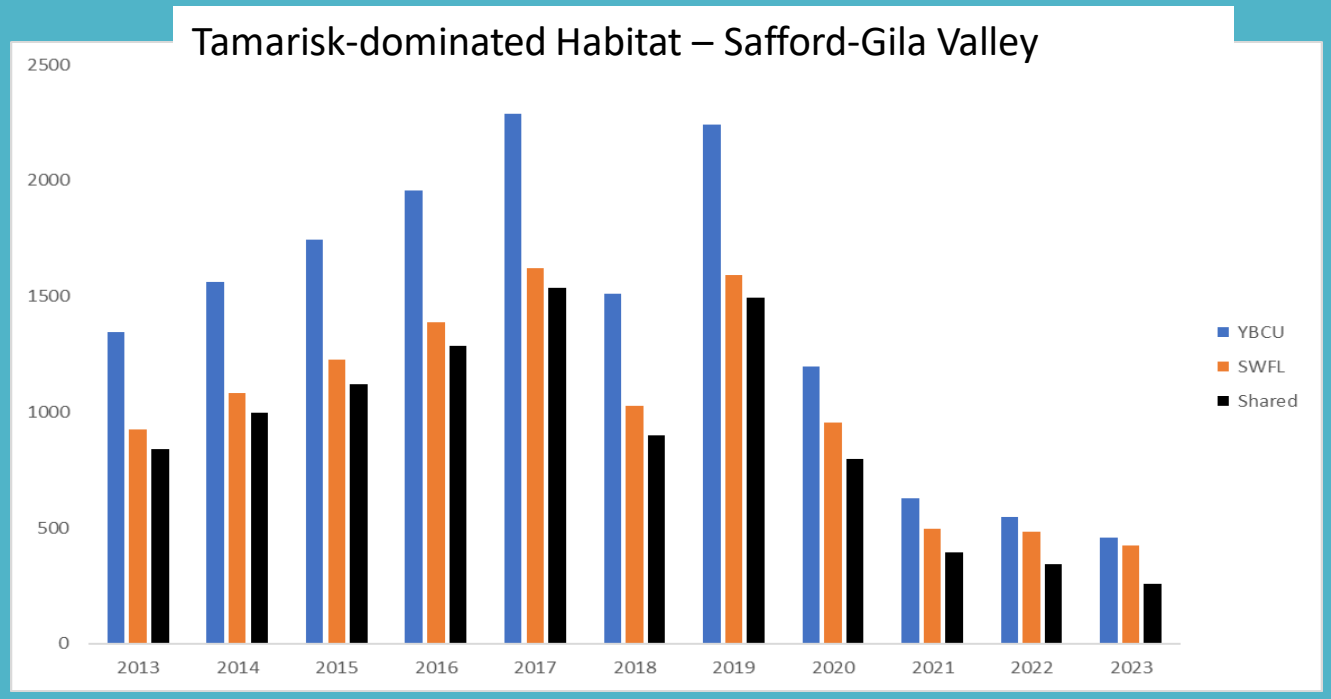


We used these maps to measure the amount of predicted **SWFL**, **YBCU**, and **SWFL-YBCU** (shared) habitat

- in Native-dominated Cliff Gila study area and the Tamarisk-dominated Safford-Gila study area
- created bar graphs to see changes in the amount of predicted habitat over space and time

Then, we compared changes in the amount of predicted SWFL, YBCU, and SWFL-YBCU (shared) habitat per year with our 2020-2022 SWFL and YBCU survey results

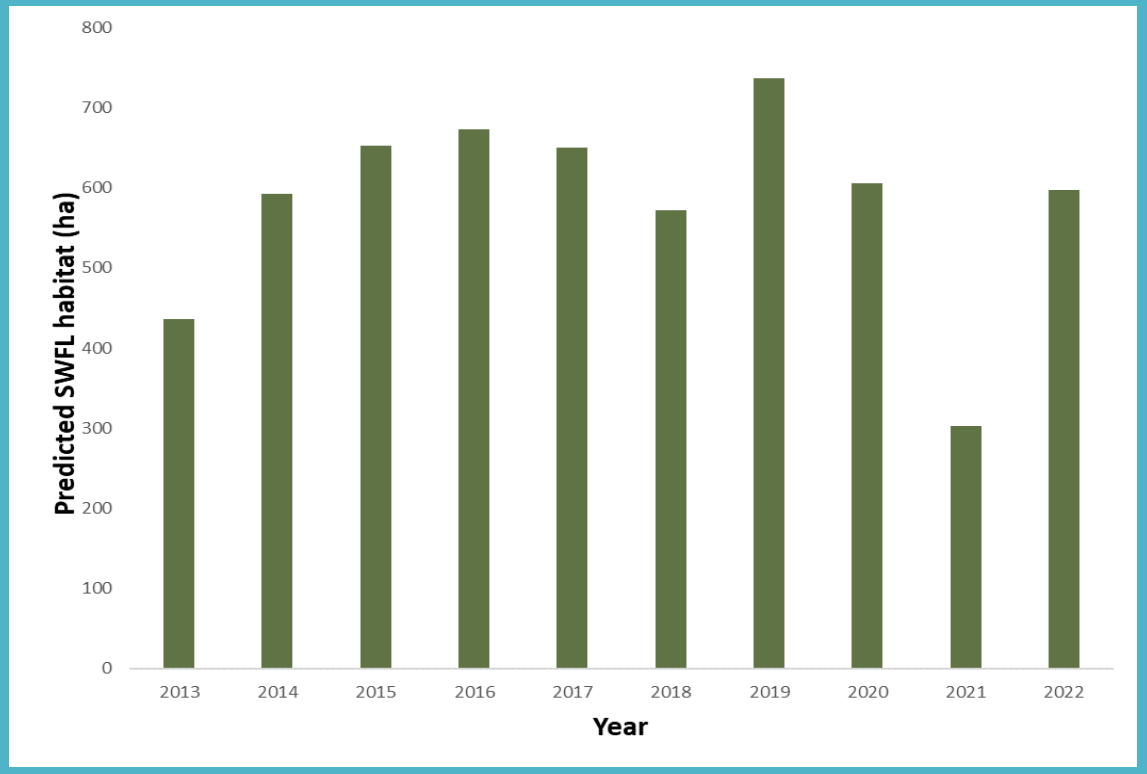


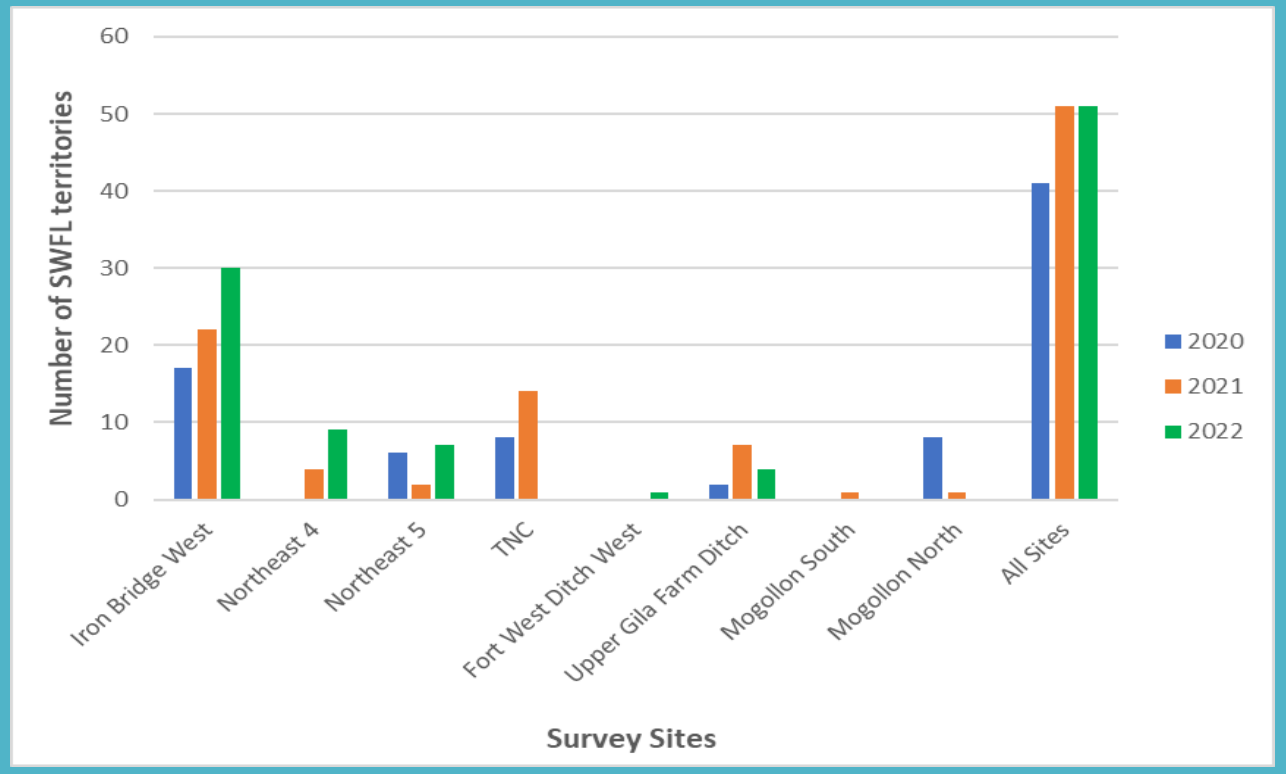


Changes in amount of SWFL Habitat and SWFL territories in Native-dominated Cliff-Gila Valley Riparian Habitat

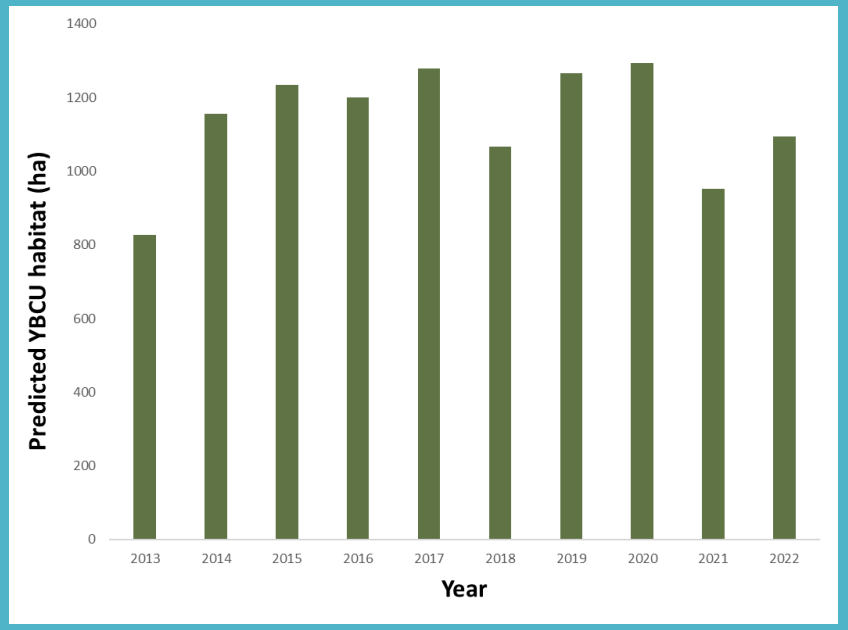
- **SWFL** habitat mostly increased from 2013 to 2020
- Then decreased in 2021 by over 50% of the maximum predicted habitat in 2019
- The next year (2022) it rebounded to just below the 2020 amount

- Within the Valley (all study sites), the estimated number of **SWFL** territories decreased in 2021, then was stable in 2022
- In contrast, site-level comparisons showed considerable variability in the number of territories from year to year

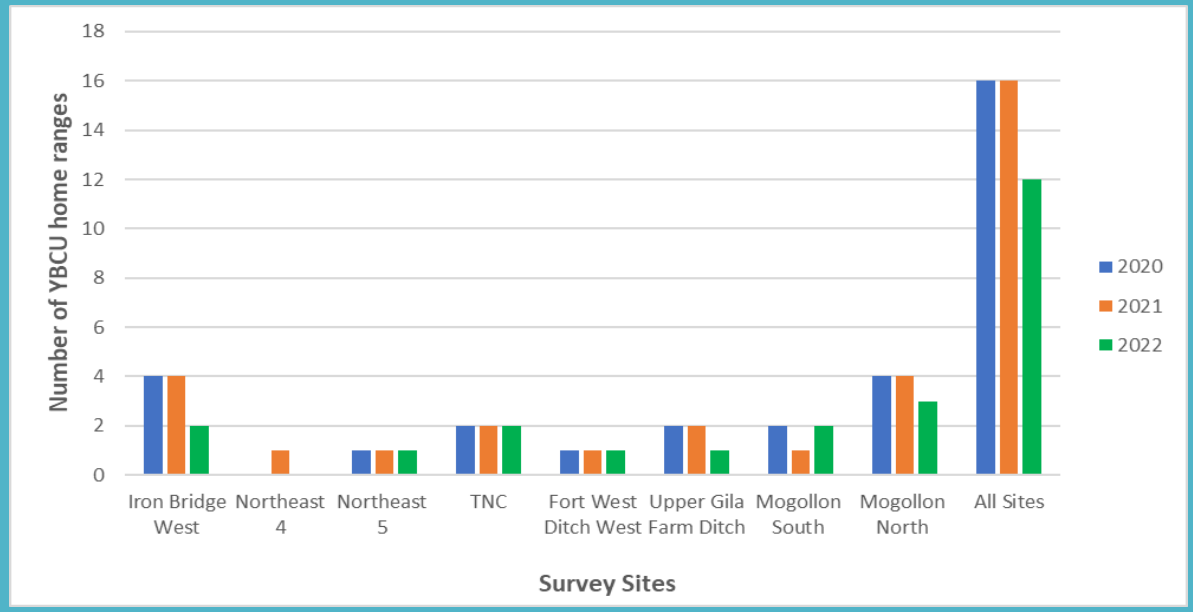




Changes in amount of YBCU Habitat and YBCU Numbers in Native-dominated Cliff-Gila Valley Riparian Habitat



- Amount of **YBCU** habitat increased from 2013 to 2020
- Then decreased by 26% in 2021
- The next year it increased 15% from the 2021 low



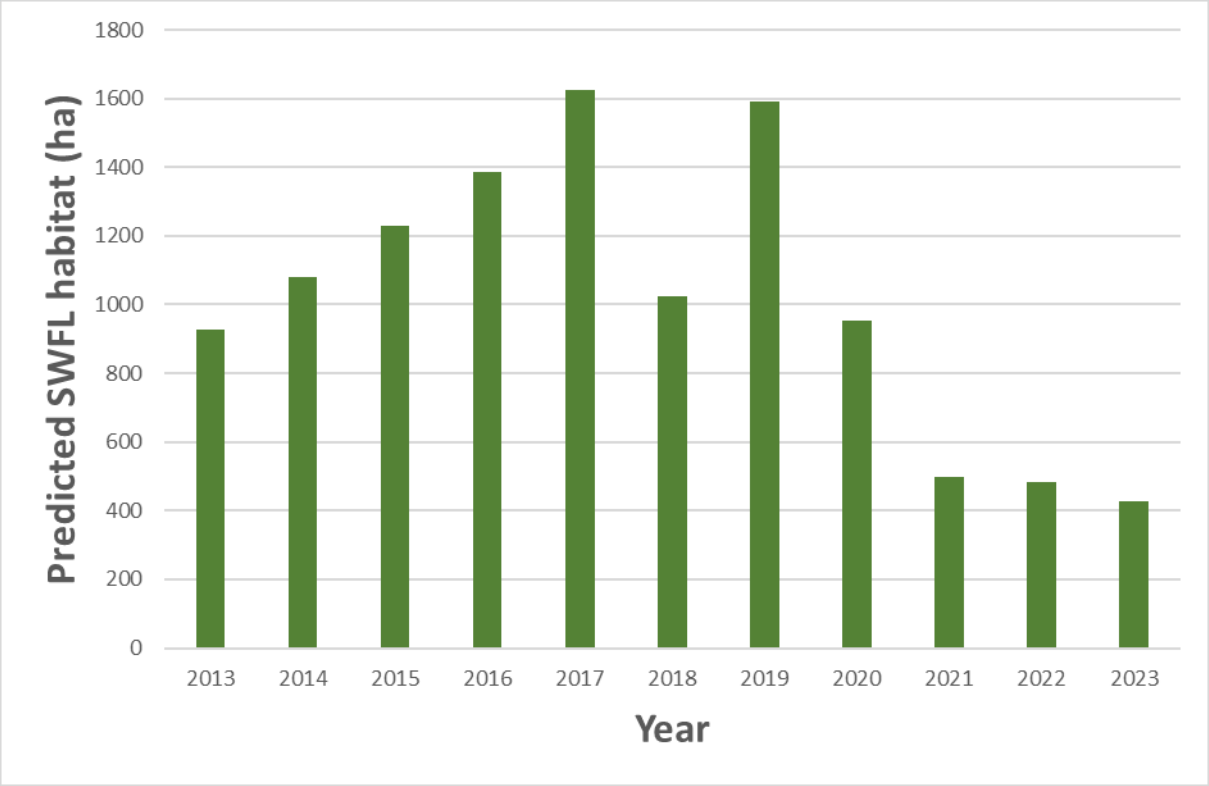
- The estimated number of **YBCU** home ranges Valley-wide (all study sites), was 16 in 2020 and 2021, then decreased to 12 in 2022

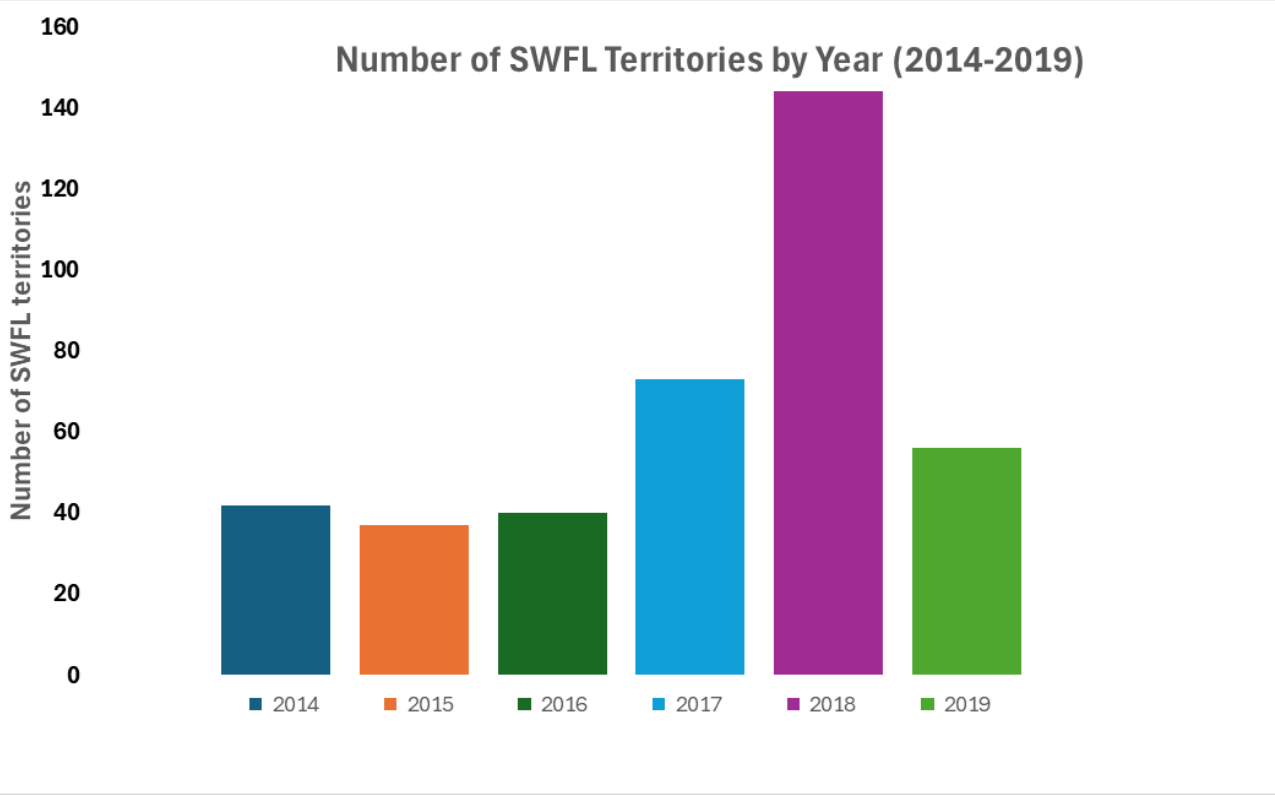
- Comparing sites:
  - 3 of 8 sites showed no change in the number of YBCU across the three years
  - 3 of 8 sites showed a decrease in the number of cuckoos in 2022

Changes in amount of SWFL Habitat and SWFL territories in Tamarisk-dominated Safford-Gila Valley Riparian Habitat

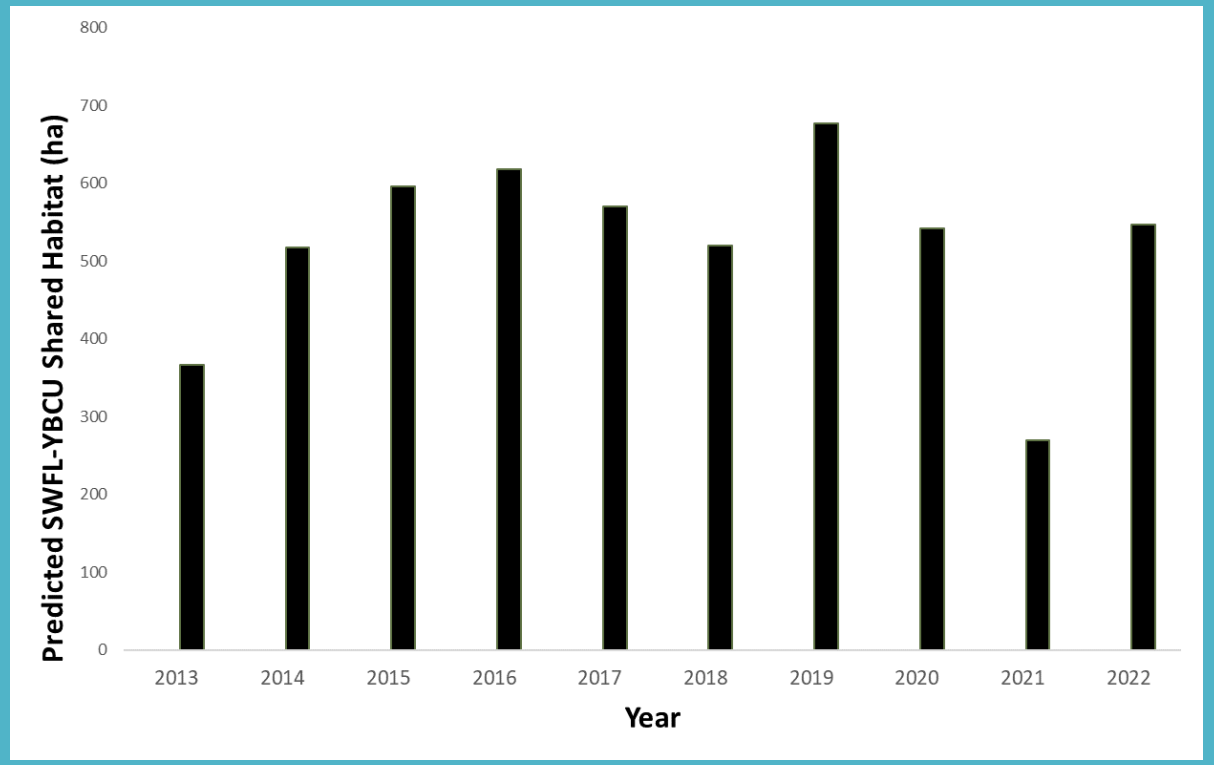
- **SWFL** habitat mostly decreased dramatically after 2020
- In 2018 one site was completely burned in April
- Tamarisk Beetle arrived at the Gila Box 2020, but didn't reach our study area until July 2022
- By 2023, Tamarisk Beetles were throughout and heavily defoliated all study sites

- SWFL Territories across years showed stability from year except in 2018 where observed a huge increase.
- The questionable date is between 2020-2022 when data was not collected.



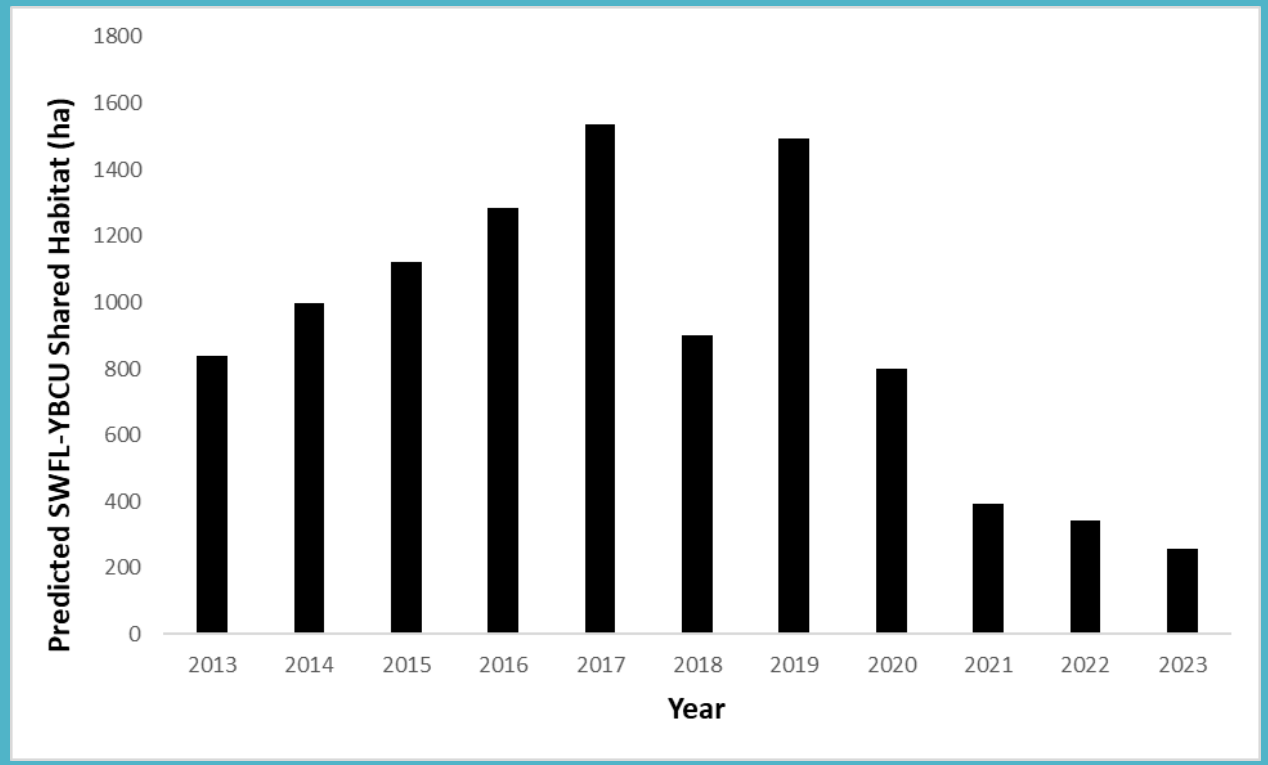


Changes in amount of SWFL-YBCU (Shared) Habitat in Native-dominated Cliff-Gila Valley and Tamarisk-dominated Safford-Gila Valley



Native-dominated Habitat – Cliff-Gila Valley

The amount of shared predicted habitat fell by 50% from 2020 to 2021



Tamarisk-dominated Habitat – Safford-Gila Valley

In the Safford-Gila, the amount of shared predicted habitat fell after the arrival of the Tamarisk Beetle

We examined the relationships between model-predicted SWFL and YBCU habitats and streamflow to gain insights into its effects on the quality, persistence, and resiliency of riparian habitats and inform management and conservation planning and actions for the species

- We completed analysis of the Cliff-Gila data and are currently analyzing the Safford-Gila data
- Our results indicate that the variability in the amount of riparian habitat within the Cliff-Gila Valley is attributable, at least in part, to the Gila River's seasonal flows
- Specifically, June daily mean flows explained significant amounts of the variability in flycatcher and cuckoo predicted habitats
- Oct-May precipitation was, in turn, a powerful predictor of June flows, explaining 57-67% of the variability
- Mean daily June flows from 2013 to 2022 were below-average in 5 of the 10 years, with a pronounced drop in 2021 and 2022, coinciding the sizeable decreases in **SWFL** and **YBCU** predicted habitat in 2021

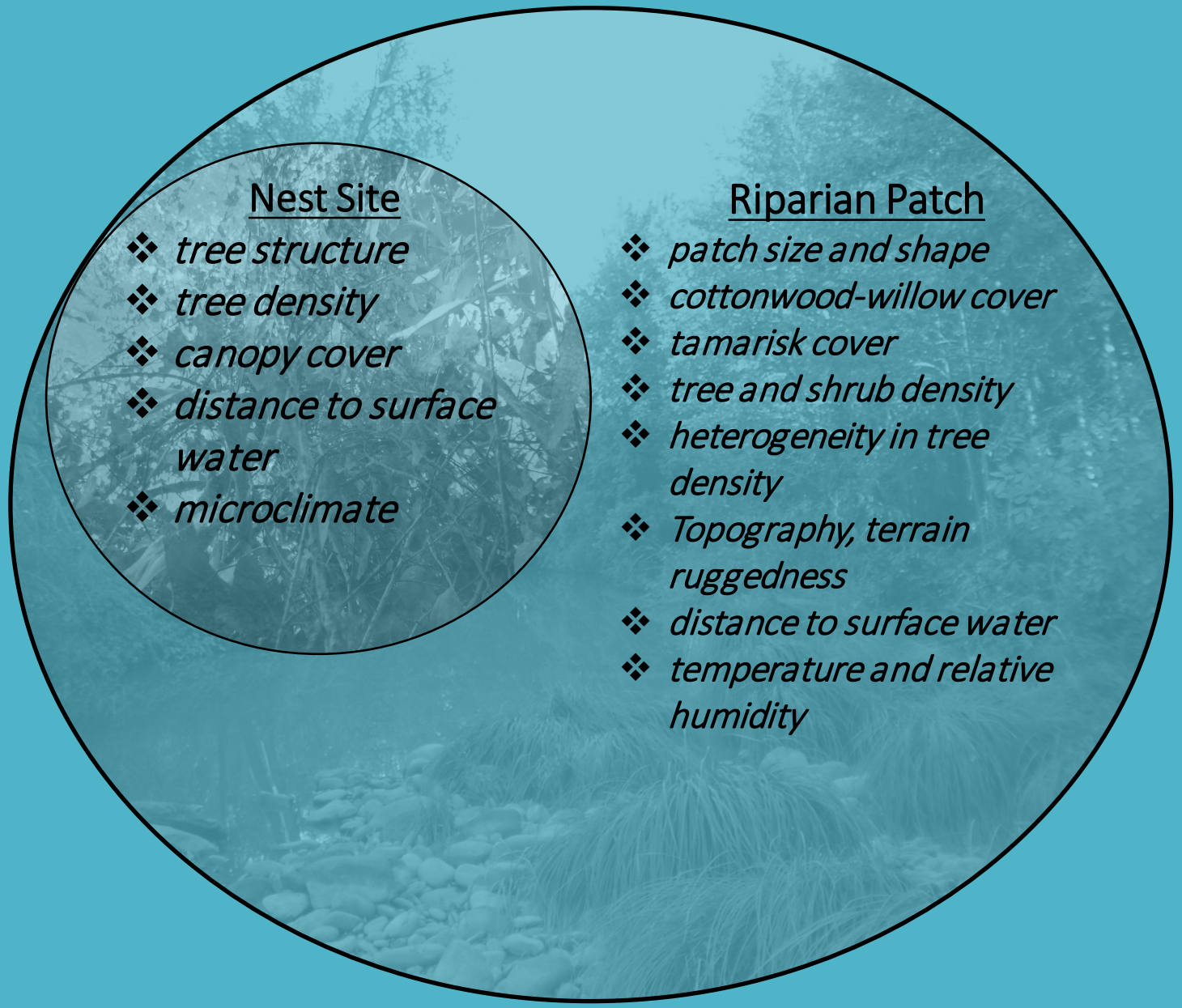
Management and Conservation Implications

Expected changes in human activity (e.g., development, increasing demand for water) and climate will threaten to change the hydrological regime necessary to establish and maintain riparian vegetation and will likely lead to reduced vigor and geographic extent, and increased fragmentation of the riparian habitats required by the SWFL, YBCU, and other riparian birds

Native-dominated riparian areas can provide habitat for SWFL, YBCU, and other riparian species and they are resilient to the effects of Tamarisk Beetles. Restoration actions should promote the creation of native-dominated riparian habitats, including hydrological conditions that enable its persistence

Climate change adaptation and planning to provide for riparian bird conservation should include enhancing connectivity of habitat and habitat protection. Consequently, alterations to the natural flow regime, especially during periods of low flows, require careful consideration by water and natural resource managers, in short- and long-term planning and ensure the persistence of riparian habitats in the Southwest

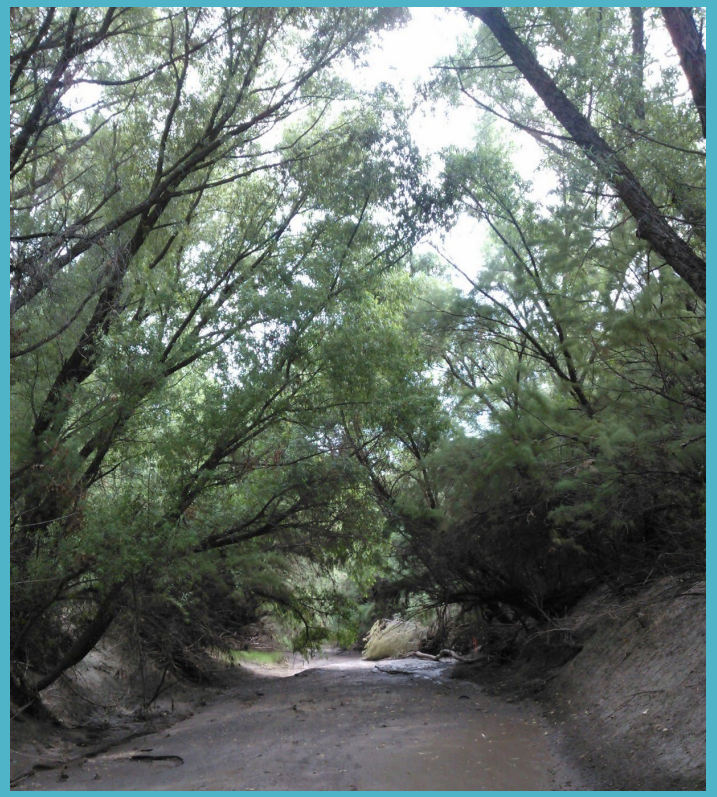
Occupancy Models



Landscape

- *Amount of cottonwood-willow, tamarisk in patches*
- *riparian patch fragmentation*
- *heterogeneity in cover types*
- *extent of upland cover types*
- *area of mesquite cover*
- *area of agriculture, human development*
- *Topography, terrain ruggedness*

Gila River (Safford) Streamflow Models



Tamarisk Leaf Beetle Impacts on SWFL and YBCU Habitat

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