Quantifying Impacts of Surface Water and Ground Water Depletion on Avian Communities in Desert Riparian Woodlands of the Southwestern U.S.

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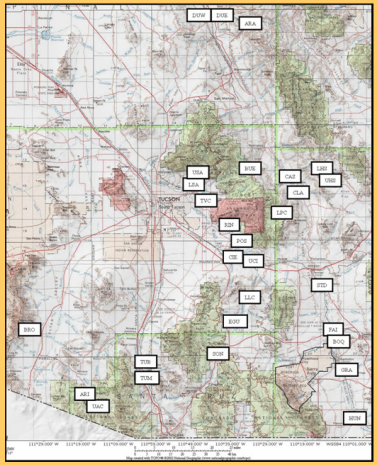
INTRODUCTION:

Desert riparian woodlands in the southwestern U.S. are an extremely important resource because they constitute <1% of the landscape, yet support >50% of breeding bird populations. Desert riparian woodlands also provide shelter and critical food resources for many species of long-distance, neotropical migrant birds during their spring and fall migrations across the southwest. Groundwater withdrawal (and subsequent loss of surface water) to support urban development, agriculture, mining, etc. has the potential to degrade or eliminate desert riparian woodlands throughout the region, including those along the San Pedro River adjacent to Fort Huachuca Military Reservation, Arizona (Fig. 1). Rapid lowering of ground water tables is known to kill riparian vegetation and reduce or eliminate surface water flows in riparian systems (Fig. 2). What's less clear is how reductions in surface water flows and long-term declines in the health of riparian vegetation will affect populations of breeding and migratory birds in the region (Fig. 2).

Figure 1. Map of southeastern Arizona showing locations of 28 study sites, including 3 study sites (FAI, BOQ, GRA) along the San Pedro River adjacent to Fort Huachuca Military Reservation (bounded by black line).



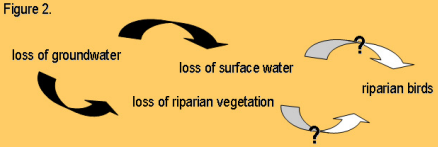
OBJECTIVES:

1. Examine connections between ground water, surface water, and the health of riparian bird communities in the southwest.
2. Develop models so that resource managers on military lands (and elsewhere) can predict how future changes in surface-water and ground-water levels will affect riparian bird communities.

PREDICTIONS:

1. Surface water within a 50-m radius of bird survey points is positively associated with bird species richness and relative abundance (for all species combined and for common species).
2. Dead or dormant riparian vegetation within a 50-m radius of bird survey points is negatively associated with bird species richness and relative abundance (for all species combined and for common species).

Figure 2.



METHODS:

• With the aid of a GIS, we identified 28 study sites (Fig. 1) that were broadly similar in terms of their elevation, stream order, topography, and vegetation type, but varied in terms of the health of riparian vegetation and the amount of surface water present (i.e., from ephemeral to perennial streams).

• During the peak of the bird breeding season (April-June), we estimated bird relative abundance and species richness during 4 replicate bird surveys along point-count survey routes at each site (we surveyed 16 sites in 2006, 6 sites in 2007, and 6 sites in 2008).

• We estimated the surface area (m^2) of standing pools and flowing segments of water within a 50-m radius of bird survey points at each site following each of the 4 replicate bird surveys. Using these data, we calculated values for two water variables: "Average Surface Water" and "Number of Visits with Water".

• We estimated the volume of both live and dead (or dormant) vegetation by species into 3 height classes (Understory = 0-2.5 m, Midstory = 2.5-5 m, and Overstory = 5-20 m) within a 50-m radius of bird survey points at each site using the point-line intercept method.

STATISTICAL ANALYSES:

• We used factor analysis to reduce our large set of vegetation variables (n = 44) to a smaller set of uncorrelated factors (n = 11).

• We employed an Information-Theoretic Approach to determine support for alternative *apriori* models describing associations of surface water, vegetation health, etc. with bird species richness and relative abundance (for all species combined and for 5 common species). We included an intercept-only model in each model set.

• Models were run using the Linear Mixed Model platform in SPSS to account for the lack of independence among bird survey points (n = 337) nested within study sites. We computed Akaike's Information Criterion (AIC_c) and ranked models based on ΔAIC_c values.

• To calculate parameter estimates, we selected the variables/factors from our top-ranked models (Royall 1997) to conduct post-hoc model selection using all combinations of variables/factors. We then model-averaged our parameter estimates and adjusted our standard errors to account for model-selection uncertainty.

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Table 1. Results from *apriori* model selection showing top-ranked models (ranked by ΔAIC_c values) for both community- and species-level bird parameters.

Top-ranked Models (n = total models in candidate set)	K	AIC_c	ΔAIC_c	w_i
Total Relative Abundance (n = 31)				
All Live Understory Veg, Number of Visits with Water, Interaction	6	1726.35	0.00	0.35
All Live Understory Veg	4	1726.57	0.22	0.31
Cottonwood Overstory & Other Live Overstory Veg, All Live Understory Veg	5	1729.28	2.92	0.08
Number of Visits with Water	4	1729.84	3.48	0.06
Cottonwood Overstory & Other Live Overstory Veg, Number of Visits with Water, Interaction	6	1730.12	3.77	0.05
Breeding Relative Abundance (n = 31)				
All Live Understory Veg, Number of Visits with Water, Interaction	6	1629.12	0.00	0.44
All Live Understory Veg	4	1629.76	0.64	0.32
Cottonwood Overstory & Other Live Overstory Veg, Number of Visits with Water, Interaction	6	1632.64	3.52	0.08
Cottonwood Overstory & Other Live Overstory Veg, All Live Understory Veg	5	1632.92	3.80	0.07
All Live Understory Veg, Number of Visits with Water, Average Surface Water	6	1634.90	5.78	0.02
Breeding Species Richness (n = 31)				
Cottonwood Overstory & Other Live Overstory Veg, All Live Understory Veg	5	1723.02	0.00	0.36
Cottonwood Overstory & Other Live Overstory Veg	4	1724.67	1.65	0.14
Cottonwood Overstory & Other Live Overstory Veg, All Live Understory Veg, All Dead Understory Veg, All Dead	7	1724.94	1.92	0.14
All Live Understory Veg	4	1725.00	1.98	0.13
Cottonwood Overstory & Other Live Overstory Veg, Number of Visits with Water, Interaction	6	1725.28	2.26	0.12
Yellow Warbler (n = 22)				
Canopy Height, Width of Riparian Veg, Cottonwood Overstory & Other Live Overstory Veg	6	793.81	0.00	0.84
Canopy Height, Width of Riparian Veg, Cottonwood Overstory & Other Live Overstory Veg, Number of Visits with Water	7	797.21	3.40	0.15
Canopy Height, Width of Riparian Veg, Cottonwood Overstory & Other Live Overstory Veg, Average Surface Water	7	802.57	8.76	0.01
Concensus (All Variables)	13	822.12	28.31	0.00
Canopy Height, Goodding Willow	5	824.88	31.07	0.00
Yellow-breasted Chat (n = 31)				
Width of Riparian Veg	4	461.46	0.00	0.40
Width of Riparian Veg, Number of Visits with Water	5	462.28	0.81	0.27
Corridor or Oasis Site	4	463.47	2.01	0.15
Corridor or Oasis Site, Number of Visits with Water	5	464.24	2.78	0.10
Width of Riparian Veg, Average Surface Water	5	464.97	3.51	0.07
Song Sparrow (n = 29)				
Width of Riparian Veg, Number of Visits with Water	5	504.30	0.00	0.27
Width of Riparian Veg, Average Surface Water	5	504.71	0.41	0.22
All Live Understory Veg, All Dead Understory Veg, Tamarisk, Average Surface Water	7	505.71	1.41	0.13
Width of Riparian Veg, Seep Willow, Number of Visits with Water	6	505.95	1.65	0.12
Width of Riparian Veg, Seep Willow, Number of Visits with Water, Average Surface Water	6	506.01	1.71	0.12

Table 2. Averaged parameter estimates from post-hoc modeling for: 1) Total Relative Abundance, 2) Song Sparrow, 3) Yellow Warbler, and 4) Yellow-breasted Chat.

1) Total Relative Abundance

Parameter	β	SE
Intercept	14.37	0.85
Cottonwood Overstory & Other Live Overstory Veg	0.89	0.50
Live Understory Veg	0.40	0.53
Number of Visits with Water	0.34	0.38
Number of Visits with Water x Cottonwood Overstory & Other Live Overstory Veg	-0.18	0.28
Number of Visits with Water x Live Understory Veg	0.18	0.25

2) Song Sparrow

Parameter	β	SE
Intercept	0.50	0.31
Riparian Veg Width	0.30	0.36
Number of Visits with Water	0.04	0.11
Average Surface Water	0.03	0.07
Tamarisk	0.14	0.21
Live Understory Veg	0.07	0.19
Dead Understory Veg	0.14	0.19
Seep Willow	0.09	0.18
Canopy Height	-0.02	0.10

3) Yellow Warbler

Parameter	β	SE
Intercept	1.92	0.40
Cottonwood Overstory & Other Live Overstory Veg	0.22	0.22
Riparian Veg Width	0.73	0.45
Canopy Height	0.06	0.16
Number of Visits with Water	0.07	0.20

4) Yellow-breasted Chat

Parameter	β	SE
Intercept	0.67	0.38
Corridor or Oasis Site	0.55	0.47
Riparian Veg Width	0.43	0.36
Number of Visits with Water	0.06	0.16
Average Surface Water	0.01	0.08

RESULTS AND DISCUSSION

We found support for Prediction #1:

- At the community level, surface water in desert riparian woodlands was positively associated with total bird relative abundance, breeding bird relative abundance, and breeding bird species richness (Tables 1 & 2).
- At the species level, surface water in desert riparian woodlands was positively associated with relative abundance of Song Sparrow, Yellow Warbler, and Yellow-breasted Chat (Tables 1 & 2; results for two other species, Summer Tanager and House Finch, were inconclusive).

We found mixed support for Prediction #2:

- Dead or dormant riparian vegetation in the overstory was negatively associated with breeding bird species richness. However, dead or dormant vegetation in the understory was positively associated with breeding bird species richness and relative abundance of Song Sparrows (Table 1).

In general, birds were more strongly associated with riparian woodlands that had an increased presence of surface water throughout the breeding season (i.e., ↑ Number of Visits with Water) rather than with more surface water per se (i.e., ↑ Average Surface Water).

MANAGEMENT IMPLICATIONS

- Riparian bird communities in the desert southwest are threatened in two ways by ground water loss: 1) should ground water levels fall to the point where surface water flows are reduced or eliminated, breeding populations of Song Sparrows, Yellow Warblers, and Yellow-breasted Chats are likely to decline; and 2) should ground water levels fall to the point that overstory vegetation begins to die back (or become dormant), the diversity of breeding bird species is likely to decline. Continued drought conditions in the region will only compound problems associated with ground water withdrawal in the foreseeable future.
- Military readiness could be jeopardized if limited resources are diverted from the military's mission at Fort Huachuca (and at other military installations throughout the desert southwest) to deal with the recovery of potentially dozens of declining populations of birds.
- Managers can predict future effects of ground water withdrawal and surface water depletion on riparian bird communities by using the predictive models developed during the current study (see Table 2).