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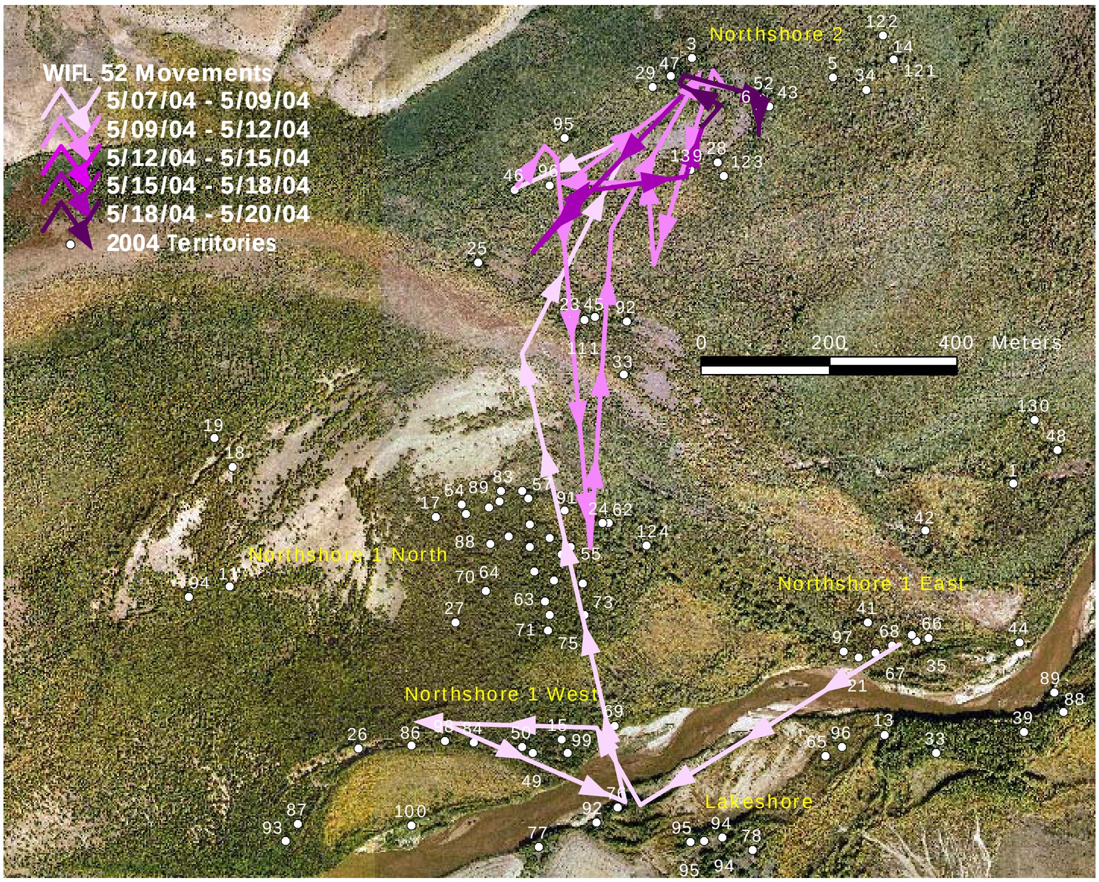
Home range, Movement, and Habitat use of the Southwestern Willow Flycatcher, Roosevelt Lake, AZ - 2004



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INTRODUCTION

The Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is a small, endangered bird that breeds only in riparian habitats scattered throughout portions of the southwestern United States (Unitt 1987, Marshall 2000). The flycatcher has suffered serious declines as riparian habitats have been lost or modified (USFWS 1993, Marshall and Stoleson 2000), and was listed as a federally endangered species in 1995 (USFWS 1995). During the past 10 years, the Southwestern Willow Flycatcher has been the subject of extensive life history research. Most of this research has been focused on studies of abundance and distribution, survivorship and mortality, large-scale movements, and breeding productivity. These studies have yielded critical information about the flycatcher's ecology, but several important habitat-use questions, all with direct conservation and management implications, remain unanswered.

The Southwestern Willow Flycatcher nests and defends breeding territories in dense riparian vegetation, usually near surface water or saturated soil. Their nesting patches are typically interspersed with vegetation of different composition and seral stages, creating a highly heterogeneous environment. Flycatcher habitat is sometimes considered as only that vegetation in which nesting occurs, although the recovery plan has a more expansive definition of habitat (USFWS 2002). Incidental observations of flycatchers occurring outside of nesting habitat suggest that the non-nesting areas within and around the riparian breeding sites may be an important component of flycatcher habitat, as evidenced by GIS models predicting flycatcher breeding habitat (Hatten and Paradzick 2002). However, the importance of these non-nesting habitats could vary from incidental to crucial, depending on the degree to which flycatchers rely on them for basic habitat needs. Effective conservation and management of the flycatcher will require a more thorough understanding of the types of nesting and non-nesting habitats used, the degree to which flycatchers use them, and the temporal and spatial extent of non-nesting habitat use.

Another important question involves the movement of individuals within riparian habitats. Preliminary banding data and anecdotal observations show that territorial flycatchers may undertake movements outside of their defended territories, in some cases over several hundred meters away (USGS, *unpub. data*). However, the nature and extent of such movements are unknown. Flycatchers may be moving outside their territories in order to acquire resources (e.g., food, water) or to obtain copulations with birds other than their mates (extra-pair copulations; Pearson 2002). The extent to which movements occur, for these or other reasons, has direct management implications in terms of habitat needs, local population estimates (under- or over-counting), and genetic diversity.

Southwestern Willow Flycatcher conservation and management is also hindered by a lack of information on flycatcher breeding territory and home range size, factors that are important in understanding habitat requirements and population trends, determining mitigation and compensation for habitat needs, and planning habitat creation and restoration projects. The answers to these questions may also be critical to understanding current population dynamics and habitat use (USFWS 2002). Such data are scarce because it is not possible to effectively follow (visually and physically) colorbanded individuals as they move through the dense riparian vegetation in which they breed.

In 2002, we began using radio-telemetry to study habitat use, movements, and home range/territory patterns. With telemetry, we have been able to follow flycatchers moving long distances (away from their defended territories), quantify home ranges for birds during different stages of the breeding season, and quantify habitat use over large areas. In 2003, we found male flycatcher home ranges and movement patterns changed significantly over the breeding season (Cardinal and Paxton 2004). This report presents results from the second year of this study on home range, movement patterns and habitat use of male flycatchers at Roosevelt Lake, Arizona.

METHODS

Study Area

This study was conducted at Roosevelt Lake, Gila County, Arizona, from May through July, 2004. Radio-tracking was conducted within the lake's floodplain, which supports a heterogeneous mosaic of riparian vegetation. The habitat patches occupied by Southwestern Willow Flycatchers are found along the lake's Salt River and Tonto Creek inflows. Dominant vegetation in the riparian floodplain consists of exotic saltcedar (*Tamarix ramosissima)* and native Goodding's Willow (*Salix gooddingii)*.

We studied flycatchers from sites that were easily accessible and had important surrounding geographic features. We used study sites that were accessible by car, had a short 20-30 minute walk from the access point or parking area, and had small hills or higher ground surrounding the site. The small hill or higher ground helped to locate flycatchers that had moved and were not detectable from the floodplain level. We captured and tracked flycatchers at study sites on both the Salt River Inflow (Lakeshore, School House North 1, and Northshore 1) and the Tonto Creek Inflow (Bermuda Flats) in order to evaluate variability between areas and habitat types (Fig 1A and 1B; see Newell et al. (2004) for Roosevelt Lake site descriptions.)

Capture and Banding

All flycatchers were caught using mist nets. Male Southwestern Willow Flycatchers were the main focus of this study, but we did attach one transmitter each to a fledgling and one adult female. We selected the birds by setting up multiple mist nets in a chosen section of a study patch, typically where there was a high density of flycatcher territories. Once mist nets were erected, conspecific vocalizations were broadcasted through speakers at each net to lure in territorial flycatchers (Sogge et al. 2001). If the target net setup was not successful, nets were left open as passive nets (with no vocalizations being projected) and were checked frequently (every 15-20 minutes) for captured birds.

To determine sex of captured flycatchers we used one or more of the following criteria:

I. If it was a recapture of a previously banded flycatcher, we checked to see if it had been genetically sexed
II. Birds were checked for presence of a brood patch (indicative of females)
III. Birds with 70 mm ≥ wing chord length have a 90% or greater likelihood of being male (USGS, *unpubl. data*), and were therefore considered males
IV. Birds previously observed defending a territory on more than two occasions were classified as males

Telemetered flycatchers were banded with a uniquely numbered color-anodized Federal Bird Band on one leg, and one metal colorband on the other (Koronkiewicz et al. 2005). Male flycatchers were classified into one of the following breeding status categories: pre-nesting, nesting, post-nesting, or floater. We defined these categories as follows:

Pre-nesting- territorial flycatchers tracked before females arrived at Roosevelt Lake.
Nesting- territorial flycatchers paired with a female that was nest-building, incubating, or feeding nestlings or fledglings.
Post-nesting - flycatchers that had made a breeding attempt but were no longer exhibiting breeding behavior such as feeding fledglings, spending time with a female with young, or no longer actively defending a territory.

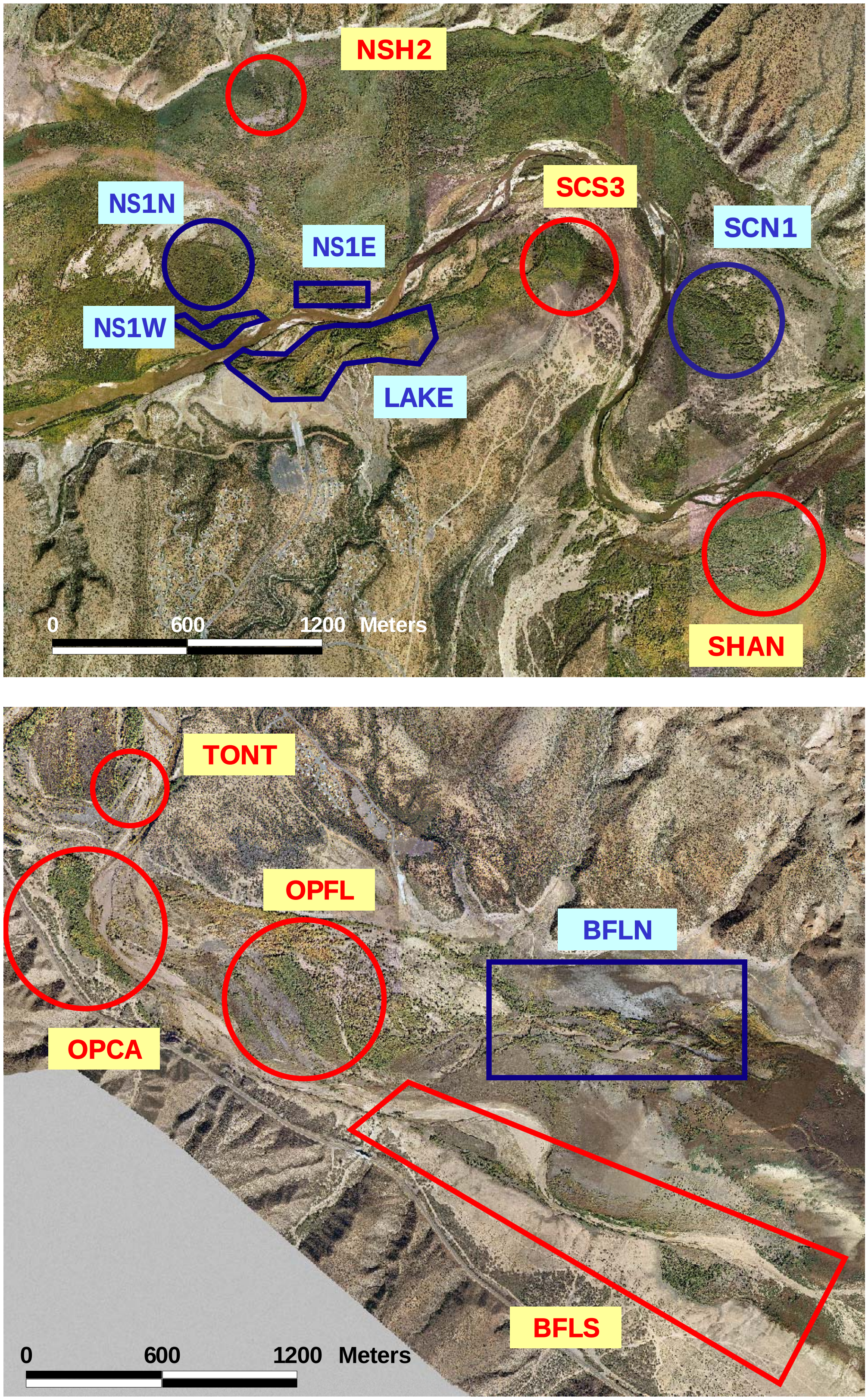


Figure 1A and 1B. Study site maps for the Salt River Inflow (A) and Tonto Creek Inflow (B). We captured Southwestern Willow Flycatchers in the areas designated in the blue colors and we tracked telemetered birds to the areas designated in red (we did not catch birds in these patches). On the Salt River Inflow, we captured birds at NS1E= Northshore 1 East, NS1W= Northshore 1 West, NS1N= Northshore 1 North, LAKE=Lakeshore, and SCN1= School House North 1. We tracked birds to: NSH2= Northshore 2, SCS3=School House South 3, and SHAN= Shangri-la. On Tonto Creek, we captured birds at: BFLN= Bermuda Flats North and we tracked birds to: BFLS= Bermuda Flats South, OPFL=Orange Peel Flats, OPCA= Orange Peel Campground, and TONT= Tonto.

Floater- non-territorial flycatchers (territorial behaviors such as singing or defending a fixed area were not observed).

We determined nesting stage (building, incubating, nestlings or fledglings) by observations of female behavior, monitoring nests, and/or utilizing Arizona Game and Fish Department's nest monitoring data (Munzer et al. 2005).

Transmitter Attachment and Tracking Methods

Transmitters and attachment method

We used Holohil LB-2N and BD-2N transmitters for this study. These are lightweight transmitters with an initial weight of 0.44 g and 0.48 g and an expected battery life of 21 days and 28 days, respectively. With the addition of a cloth backing and epoxy to set the activation wires (LB-2N only), final weight of the transmitters was 0.46 g to 0.50 g - 3.8% to 4.2% of the weight of the flycatchers (including the female and the fledgling) to which they were attached, and well below the 5% maximum weight limit typically deemed safe. We used a glue-on technique to attach the transmitters, which was found to be safe and effective during our pilot project (Paxton et al. 2002). For more information on transmitter attachment, see Paxton et al. (2003) and Cardinal and Paxton (2004).

Tracking

Tracking began the day after transmitter attachment in order to allow time for resumption of normal behavior following handling stress (Suedkamp Wells et al. 2003). We stratified points throughout the day by tracking birds during all the daylight hours. We systematically sampled these time periods by the following schedule: two consecutive mornings (we tracked birds only in the morning for two days), two consecutive afternoons (we tracked birds only in the afternoon for two days), and one midday. We tracked every bird according to this time schedule and the tracking schedule (the order in which we tracked the birds) was randomized daily, to avoid tracking birds in the same order each day. During the time period (morning, midday, or afternoon) each bird was tracked until 4-6 locations were taken with at least a half hour between an individual's locations. A half hour is assumed to give independence between each location because this is greater than the time it would take a flycatcher to move across its home range, a commonly used measure to ensure biological independence (White and Garrot 1990).

Most birds were tracked via the homing-in method, which involved approaching a bird quietly but quickly until the signal strength indicated the bird was close to the tracker. Once close to the flycatcher, the tracker moved in slowly to attempt to see the bird without affecting its behavior. Ideally, a flycatcher was located and visually observed, and the location recorded via GPS (Garmin Etrex Legend GPS Unit) after the flycatcher moved on to another location. If a flycatcher could not be detected visually (usually due to the bird staying high in the thick canopy) the location was estimated using the telemetry signal strength to indicate when the bird was less than 5 m away. When birds were tracked to extremely dense patches of foliage, the tracker triangulated from multiple positions along the patch edge until the approximate location was ascertained. On two birds, we used a triangulation method in place of homing-in. For these birds, we triangulated atop adjacent hills to ascertain the birds position by obtaining two to three angles within 3-5 minutes between locations. Other data recorded at each location were: habitat type, substrate the bird was in, the height of the vegetation where the bird was seen, vocalizations, foraging activities, and any observed interactions with other flycatchers.

Data Analysis

Home Range Analysis

Home range analysis was calculated for the flycatchers with at least 30 locations, the minimum number typically needed for home range estimates (Kenward 2001); for this report, we also included two individuals (WIFL 52 and WIFL 66) that had 28 and 29 locations. Home range was estimated using two methods: minimum convex polygon (MCP) and fixed kernel contour. Both analyses were calculated using the Animal Movement extension (Hooge and Eichenlaub 1997) in Arcview 3.3. The MCP method connects the outermost points forming a polygon; the area enclosed in the polygon is the calculated home range. We used the innermost 95% of the total number of locations to minimize the influence of the outermost locations. The advantages of the MCP method are its simplicity and its wide use in other studies (White and Garrot 1990). The main disadvantages are that it considers all area within locations as being used, even if the flycatcher was never detected in the area, and it does not distinguish between higher and lower use areas (White and Garrot 1990). The fixed kernel is a “utilization distribution” which provides the probability of a flycatcher occurring within a given area for the period it was tracked (Kernohan et al. 2001). The main advantage of the kernel estimate is that it gives higher weight to areas of high use (Kernohan et al. 2001). The main disadvantage for the method is that calculated home range changes significantly depending on the smoothing factor used. To control for this, we used a least squares cross validation method to determine the smoothing factor, which produces an objective and accurate home range estimate (Seaman and Powell 1996). We used a 95% probability kernel to estimate home range, and a 50% probability kernel to estimate a core area within that home range (Vega Rivera et al. 2003). We present both MCPs and kernels to compare and contrast the resulting home range estimates.

Movement patterns

Using the Animal Movement extension (Hooge and Eichenlaub 1997) in Arcview 3.3, we calculated several measures of movement. First, for each individual, we measured the distance between the two farthest locations to calculate the magnitude of movement. To characterize the general length of movements, we calculated the average distance between each successive location. On an individual basis, bird locations were ordered by date and time and then graduated by color to look at how birds moved during the time they were tracked.

Habitat Use and Availability

To estimate habitat availability for each flycatcher we first calculated the arithmetic mean of all its locations using spider distance analysis in the Animal Movement extension of Arcview 3.3 (Hooge and Eichenlaub 1997). Then the distance to the farthest location was calculated to define the radius of a circle, and the area within this circle was considered to be the habitat available for that bird at the time the bird was tracked (Menzel et al. 2001; see Fig. 2).

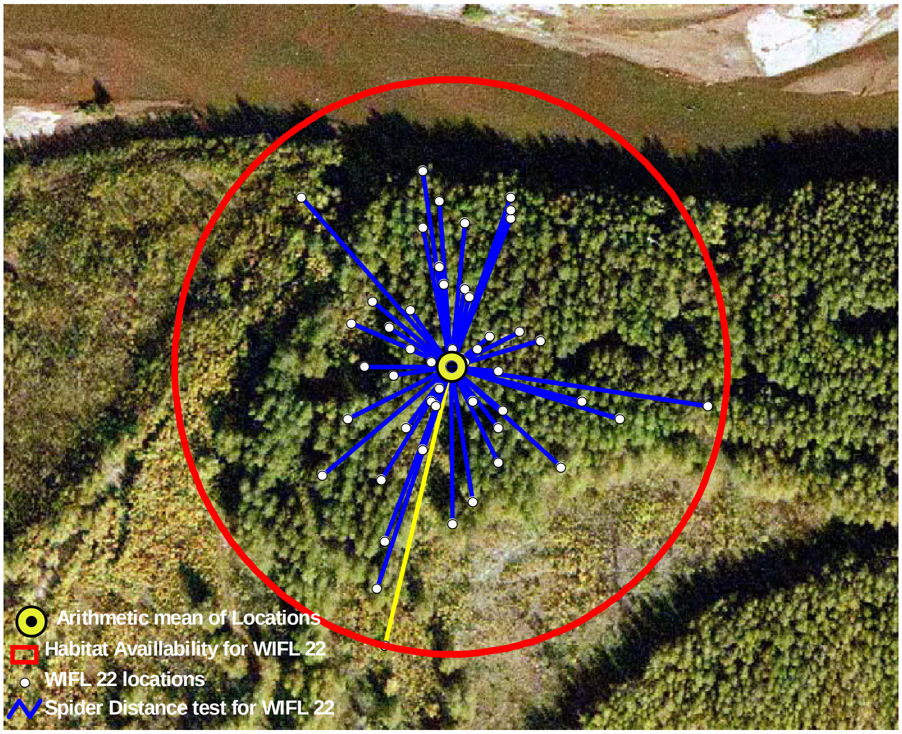


Figure 2. An example of the method used to determine habitat availability for each telemetered flycatcher. The figure shows the spider distance analysis in Arcview 3.3 and the habitat available for WIFL 22, based on the longest distance moved from the mean of the locations.

Using high-resolution, rectified aerial photographs, we classified riparian woodland habitat according to an age structure gradient (young, immature, or mature), with upland and open included as other habitat types (Fig. 3).

Young- riparian vegetation <3 years old comprised of either saltcedar or willow.
Immature- riparian vegetation <5 years old. These are small patches of tall habitat emerging from the young vegetation and were comprised of saltcedar, willow or a mixture of the two.
Mature- riparian vegetation at least 5 years old. Mature patches are focal areas for the flycatchers and they comprise most of the habitats in which flycatchers breed (Allison et al. 2003). Mature patches were further differentiated by the dominant tree(s) species they were composed of: native Goodding's Willow-dominated, exotic saltcedar-dominated, and mixed (a mosaic of both willow and saltcedar).
Open- exposed ground that had less than 5% of live woody vegetation ground cover.
Upland- all habitats dominated by Sonoran Desert Upland vegetation.
Open Water- any open water was not considered available habitat.

Habitat availability was determined by calculating the percentage of each habitat within each individual's habitat availability circle. Habitat used by each bird was determined by calculating the percentage of detection locations that occurred in each habitat type. We used a chi-squared test of heterogeneity (using JMP 5.1) to test whether the percent of habitat used differed from habitat available to each bird.

For all statistical tests, significance was assumed at $\underline{P} < 0.05$. Standard error was used as a measure of the variance around a mean (e.g., $\bar{x} \pm$ S.E.).

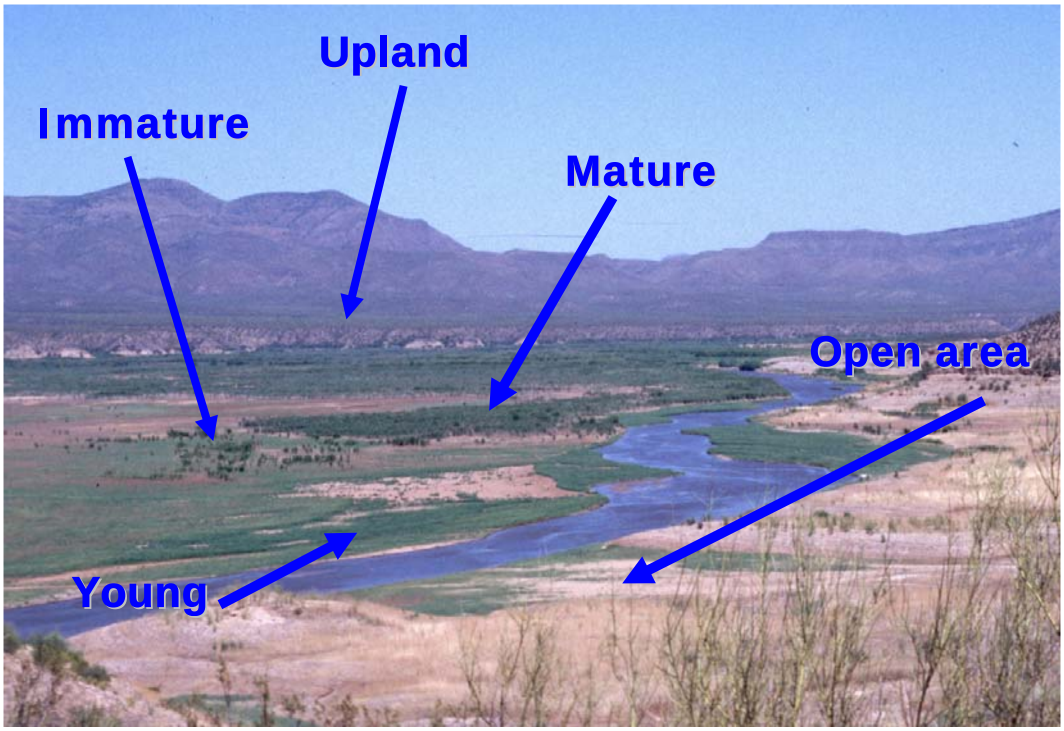


Figure 3: Photograph of the Salt River Inflow floodplain, Roosevelt Lake, Arizona, showing representatives of the five major habitat categories. Young (young vegetation under 3 years old); Immature (small patches of tall habitat younger than 5 years old); Mature patches (over 5 years old composed of native, mixed or exotic vegetation); Upland (habitat above the high water mark); and Open areas (little or no live woody vegetation).

RESULTS

Banding and Tracking Data

Fifteen males, one female, and one fledgling were caught and fitted with transmitters from May through July, 2004 (Fig. 4). Because the transmitters lasted an average of 21 days and flycatchers were caught throughout the season, breeding status of each bird varied based on when it was caught (Fig. 5). During the study, we spent over 340 tracking hours to collect 658 locations on all telemetered flycatchers. We collected enough location data (≥28 locations) for 12 of the 15 male birds to calculate home range estimates; the average number of locations collected for these 12 birds was 48 (Table 1). Transmitters fell off the remaining three male flycatchers before batteries expired and before we could collect enough locations to estimate home range. We examined only movement patterns for the fledgling (WIFL 77) and the adult female (WIFL 75).

Thirteen of the 20 flycatchers used in the 2003 telemetry study returned to Roosevelt Lake in 2004 resulting in a 65% return rate. This rate is comparable to the general return rate for banded flycatchers at Roosevelt Lake from 2000-2004 (53-69%; Newell et al. 2004). Three flycatchers from the 2003 season were re-captured and fitted with new transmitters (Table 1). All recaptured flycatchers used in the 2003 telemetry study had fully re-grown their back feathers and no transmitters were still attached.

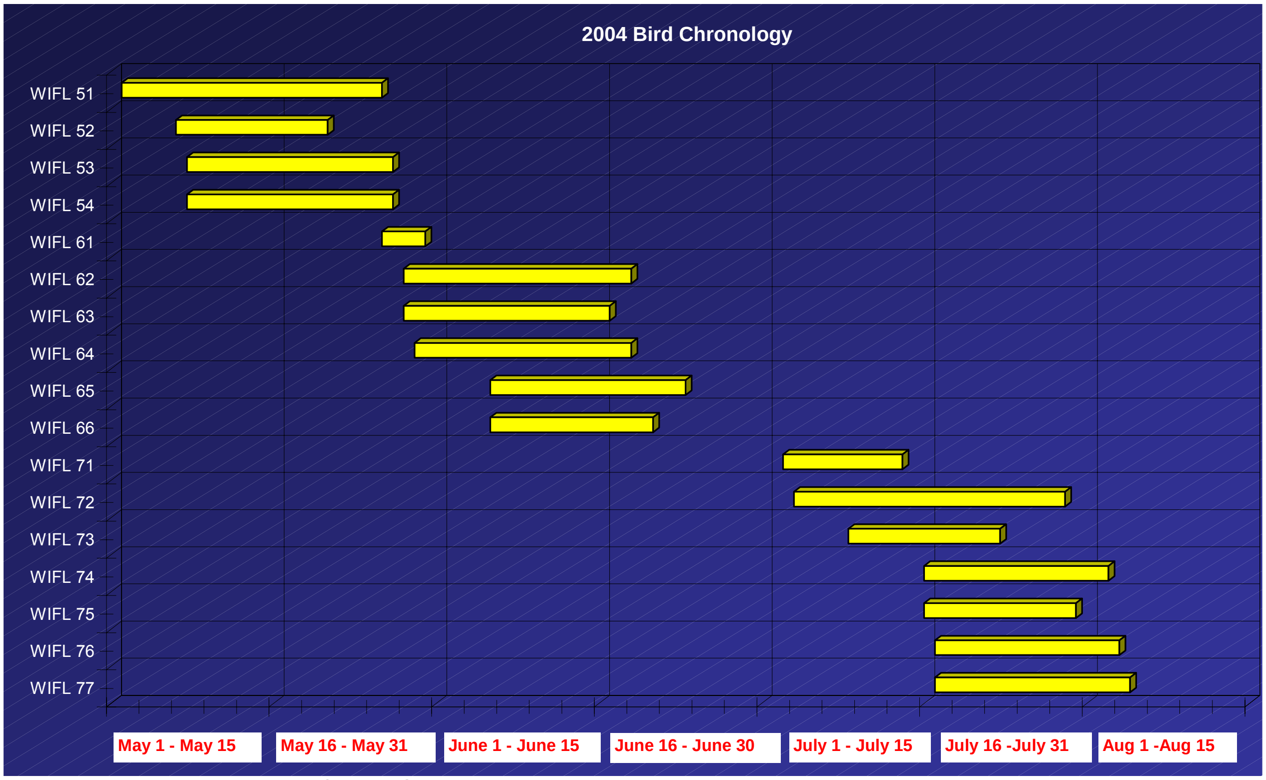


Figure 4: Tracking periods of all 17 Southwestern Willow Flycatchers telemetered at Roosevelt Lake, 2004. Includes the one female (WIFL 75) and the one fledgling (WIFL 77). Length of bar indicates relative length of time that each individual flycatcher was tracked.

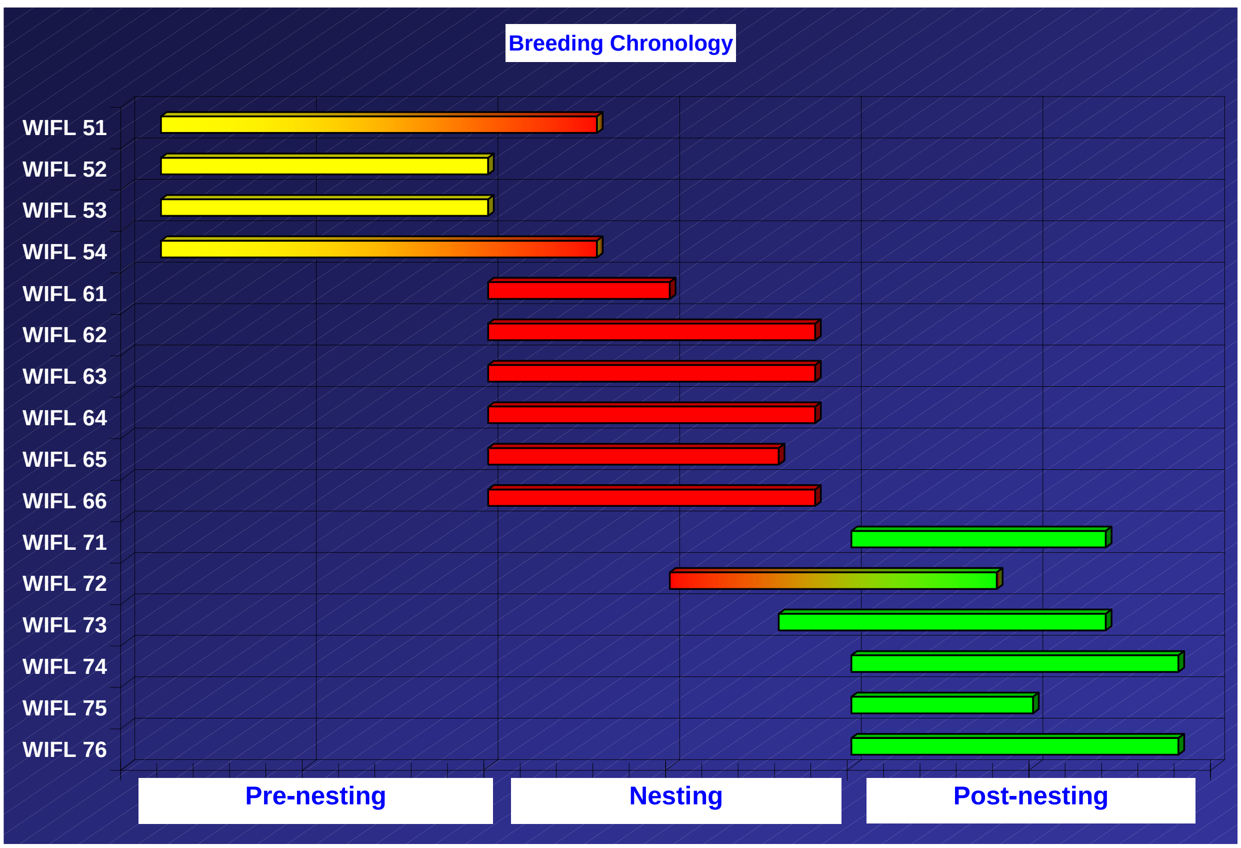


Figure 5: Breeding chronology for all telemetered Southwestern Willow Flycatchers at Roosevelt Lake, 2004 except for the fledgling (WIFL 77). The X -axis represents breeding status, with each color representing a different status. Transitional colors indicate a change in breeding status during the tracking period.

Table 1: Capture information for all Southwestern Willow Flycatchers telemetered at Roosevelt Lake in 2004. The table includes band combination, band number, age, sex, site (where the bird was territorial), territory number, 2003 telemetry status, breeding status, dates tracked, number of days tracked, and number of points collected.

WIFL #	Band Combo	Band Number	Age	Sex	Site	Territory #	2003 Telemetry Bird?	Breeding Status	Dates Tracked	# of Days Tracked	# of Points
51	D:WKW	2290-24319	A6Y	M	NS1E	51/35	NO	Pre-nesting/ Nesting[1]	5/1-5/25	25	60
52	DYD:D	2290-24320	4Y	M	NSH2	52	NO	Pre-nesting	5/6-5/20	15	29
53	D:ZKZ	2290-24309	4Y	M	NS1W	49	YES, WIFL 22	Pre-nesting	5/7-5/26	20	60
54	RWR:D	2290-24321	4Y	M	NS1W	50	NO	Pre-nesting/ Nesting	5/7-5/26	20	60
61	DRD:D	2290-24315	AHY	M	NS1N	64	NO	Nesting	5/25-5/29	5	9
62	KOK:D	2290-24322	ATY	M	NS1N	37	YES, WIFL 11	Nesting	5/27-6/17	22	57
63	D:WZW	2290-24301	ATY	M	NS1N	89	YES, WIFL 04	Nesting	5/27-6/14	19	40
64	D:KWK	2290-24323	TY	M	NS1N	88	NO	Nesting	5/28-6/17	21	55
65	G:WG	2210-57323	ASY	M	LAKE	95/55	NO	Nesting[1]	6/4-6/22	19	59
66	D:WOW	2290-24316	SY	M	LAKE	94	NO	Nesting	6/4-6/19	16	29
71	GYG:D	2290-24324	5Y	M	NS1E	67	NO	Post-Nesting	7/2-7/13	12	20
72	YGY:D	2290-24325	ASY	M	LAKE	32	NO	Nesting/ Post-Nesting	7/3-7/28	26	57
73	YWY:D	2290-24339	AHY	M	SCN1	7	NO	Post-Nesting	7/7-7/21	15	39
74	YWY:D	2290-24340	SY	M	BFLN	--	NO	Post-Nesting	7/14-7/31	18	34
75	D:WDW	2290-24341	SY	F	BFLN	7	NO	Post-Nesting	7/14-7/28	15	16
76	RDR:D	2290-24317	SY	M	BFLN	NA	NO	Post-Nesting	7/15-8/1	18	8
77	DD:UNB	2290-24318	HY	U	BFLN	NA	NO	N/A	7/15-8/2	19	26

Color band color codes: **Z**=gold, **K**=black, **D**=blue, **G**=green, **O**=orange, **R**=red, **W**=white **Y**=yellow
Age: **HY=** Young of the year, **SY=** 2 years, **AHY**=2 years or older, **TY**=3 years, **ASY**=3 years or older, **4Y**=4 years, **ATY**=4 years or older, **5Y**=5 years old, **A4Y**=5 years or older, **A6Y**= 7 years or older.
Site codes: **NS1E=** Northshore 1 East, **NS1W**: Northshore 1 West, **NS1N**: Northshore 1 North, **NSH2**: Northshore 2, **LAKE**: Lakeshore, **SCN1**: School House North 1, **BFLN**: Bermuda Flats North. For Site Descriptions see Newell et al. 2004.
[1] Birds with two female mates= polygnous

Home Range and Movement Patterns

Home range sizes varied from 0.15 to 360 ha ($\bar{x}$ = 53.03 ± 31.66) using 95% kernel contour and 0.13 to 178.61 ha ($\bar{x}$ = 39.94 ± 19.14) using the MCP method with 95% of the points (Table 2; Fig. 6). The longest distance between detection points for each individual ranged from 37 to 2851 m ($\bar{x}$ = 645 ± 286) and mean consecutive movements ranged from 14 to 756 m ($\bar{x}$ = 124 ± 61.78; Table 2). The MCP and kernel estimates resulted in similar size home ranges, but the area and habitat encompassed within these home ranges were dissimilar. For example, using the MCP estimate for a post nesting bird (WIFL 72 Fig. 8A), the area encompasses habitat that the bird did not normally use, such as uplands, while the kernel area estimates habitat within the riparian vegetation. Yet the size of the home range estimates are similar: 169.02 ha with MCP and 176.34 ha using 95% kernel. For post-nesting flycatchers the kernel method home range estimates were larger than the MCP estimates.

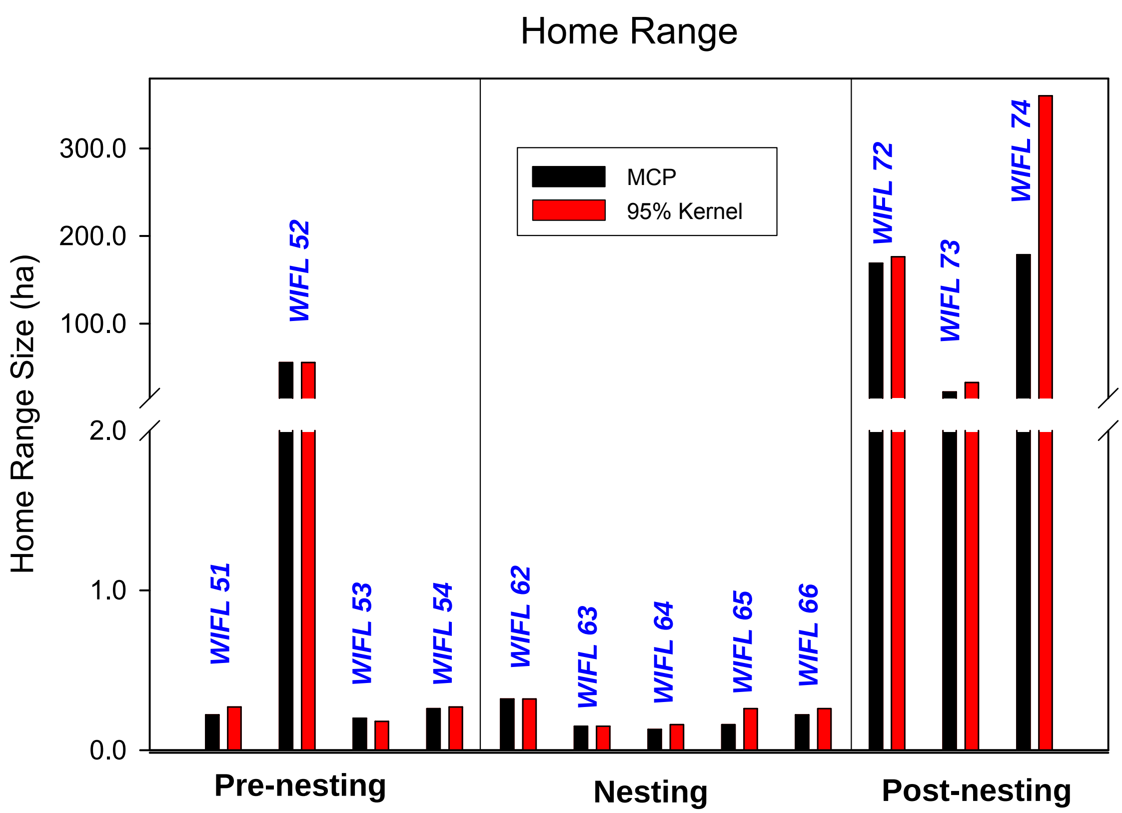


Figure 6. Home range sizes for all adult male flycatchers with ≥28 locations. Black bars are the MCP estimate and red bars are 95% Kernel contour estimate for home range. The X-axis is breeding status and the Y-axis is the size of the home range.

In general, home range sizes changed significantly through the breeding season (P= 0.04). Three of the four pre-nesting flycatchers had home ranges < 1 ha, while the fourth bird, WIFL 52, had an extremely large home range of over 55 ha. During the nesting season all home ranges were < 0.5 ha ($\bar{x}$ = 0.23 ha using 95% kernel, and $\bar{x}$ = 0.20 using MCP), with the longest movements averaging 70 m. At the end of the season, the post-nesting birds had the largest home ranges ($\bar{x}$ = 189.67 ha using 95%

kernel, $\overline{x}$ = 123.19 ha using MCP). All three birds tracked during the post-nesting season made at least one movement over 1 km (Table 2).

We observed a variety of home range and movement patterns. Most nesting birds made small movements and had home ranges that were contiguous (Fig. 7B). However, several non-nesting birds had non-contiguous home ranges and made long distance movements of over 2 km: WIFL 72 (Fig. 8A) had three areas of high frequency use, and WIFL 74 made multiple long distance movements (Fig. 8B). We observed overlapping home ranges in the pre-nesting (Fig. 7A), nesting (Fig. 7B), and in the post-nesting season (not shown).

Finally, we conducted a small pilot study to determine safety of radiotracking female and fledgling Southwestern Willow Flycatchers. We caught and tagged one female and one fledgling at Bermuda Flats North in mid-July. The female was tagged just after its single nestling had fledged and was tracked for 15 days until the transmitter prematurely fell off. The female exhibited aggressive behavior in two ways: the bird vocalized when the tracker approached within 25 m of the nest area and defended its fledgling more aggressively by vocalizing with increased frequency and flying at the tracker. The female was rarely found more than 30 meters from the nest area except for one location where the bird was found 80 m away.

The fledgling was caught in Bermuda Flats North and was tracked for 26 days (see Table 1). The fledgling was caught in an area where a family group of flycatchers was observed including two adults and two fledglings that were heard making begging calls. Based on development, the fledgling had been out of the nest for approximately one to two weeks when captured. During the first 10 days of tracking the fledgling stayed within 50 m of the capture location and was observed with another fledgling and adults; at 11 days after capture, the fledgling made a movement of ≈1.5 km to the edge of the lake in non-breeding habitat just north of Bermuda Flats South; no other flycatchers were detected with the fledgling. Three days after this initial movement, the bird moved across Roosevelt Lake and was detected at Shangri-la (on the Salt River) for two days. The fledgling was not detected for a full day and then the following day was detected back on the Tonto end where it had been seen before the trans-lake movement.

Table 2: Area used and movement patterns for male Southwestern Willow Flycatchers with 28 or more locations. Table shows home range sizes using a minimum convex polygon and kernel with 95% and 50% contours, longest distance moved between points and mean distance between consecutive points.

			Fixed Kernel			
WIFL #	**Breeding Status**	**MCP area (ha)**	**95% (ha)**	**50% (ha)**	**Longest distance between locations (m)**	**Mean distance of consecutive movements (m)**
WIFL 51	Pre-nesting	0.22	0.27	0.05	62	20 (± 1)
WIFL 52	Pre-nesting	55.56	56.68	9.68	722	239 (± 39)
WIFL 53	Pre-nesting	0.2	0.18	0.02	42	18 (± 1)
WIFL 54	Pre-nesting	0.26	0.27	0.05	99	21 (± 2)
WIFL 62	Nesting	0.36	0.32	0.05	99	26 (± 3)
WIFL 63	Nesting	0.15	0.15	0.01	40	18 (± 2)
WIFL 64	Nesting	0.13	0.16	0.03	37	14 (± 1)
WIFL 65	Nesting	0.16	0.26	0.05	123	22 (± 3)
WIFL 66	Nesting	0.22	0.26	0.03	50	18 (± 2)
WIFL 72	Post-nesting	169.02	176.34	47.4	2341	161 (± 49)
WIFL 73	Post-nesting	21.95	32.63	4.69	1275	175 (± 42)
WIFL 74	Post-nesting	178.61	360.05	46.43	2851	756 (± 159)

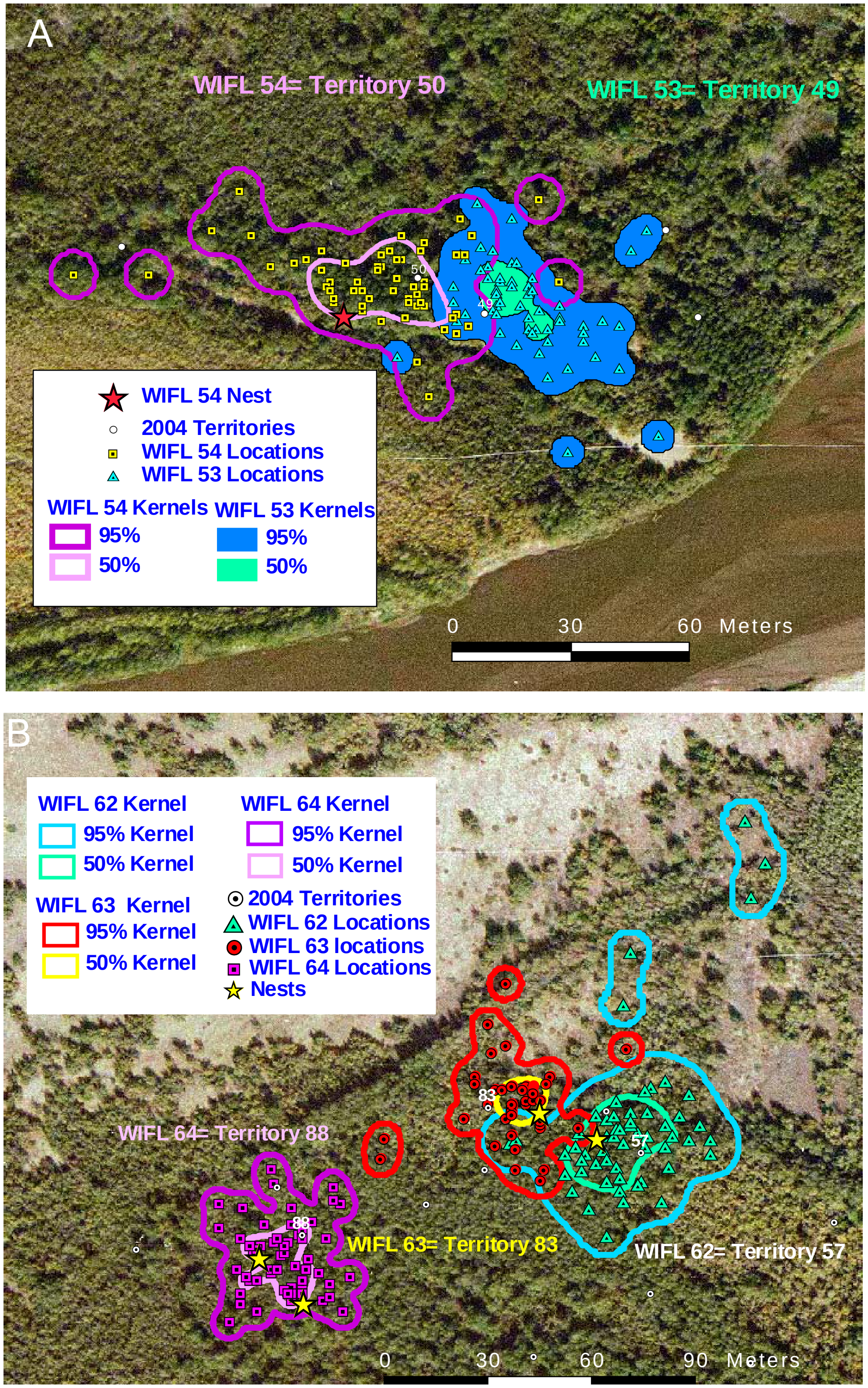
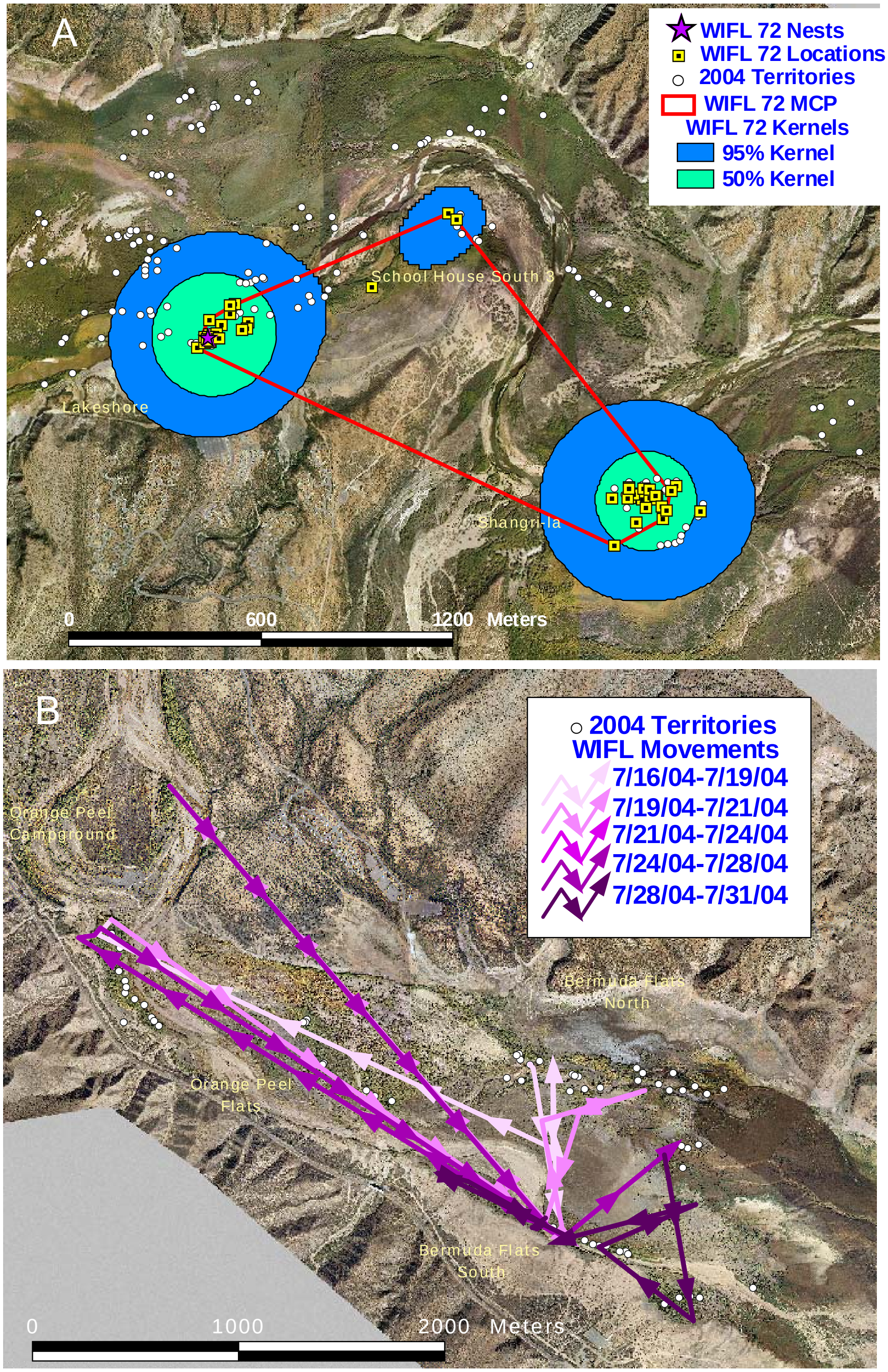


Figure 7A and 7B: Home range estimates for (A) two pre-nesting birds (WIFL 53 and WIFL 54 from in Northshore1 West) and (B) three nesting birds (WIFLs 62, 63, 64 from Northshore 1 North). Home ranges were estimated using 95% and 50% probability of occurrence contours.



Figures 8A and 8B: (A) Home range estimates for a post-breeding bird (WIFL 72) and, (B) Post-breeding movement patterns of WIFL 74. Movements are graduated by date, changing chronologically light violet to dark purple.

Habitat Use

Overall, male Willow Flycatcher habitat use differed significantly from habitat availability ($P<0.001$). The mixed mature riparian habitat was used more often than all other habitat types (Fig. 9). Fifty-three percent of recorded locations occurred in mixed habitat, which was only 28% of the available habitat. Mature native and exotic habitats had low availability and were infrequently used. Differences between habitat used and available varied between individuals, and in most cases there was a significant difference (Fig. 10). Because habitat availability was quantified on an individual basis, flycatchers with larger home ranges had more "available" habitat types, while flycatchers with the smallest home ranges had the fewest.

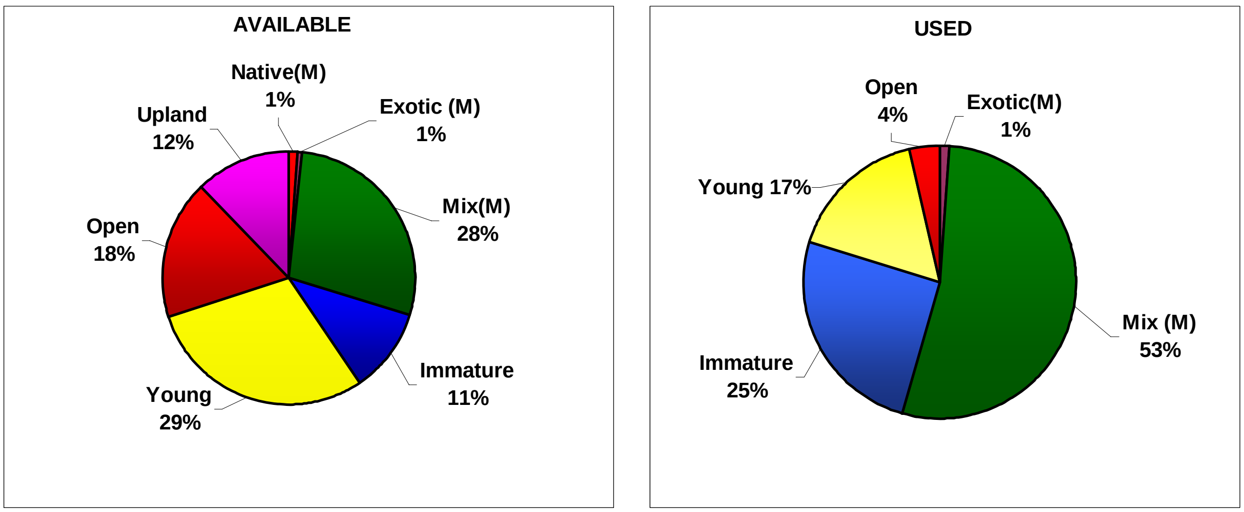


Figure 9: Percentages of habitat available versus used for all male flycatchers combined. The letter "M" represents mature habitat types.

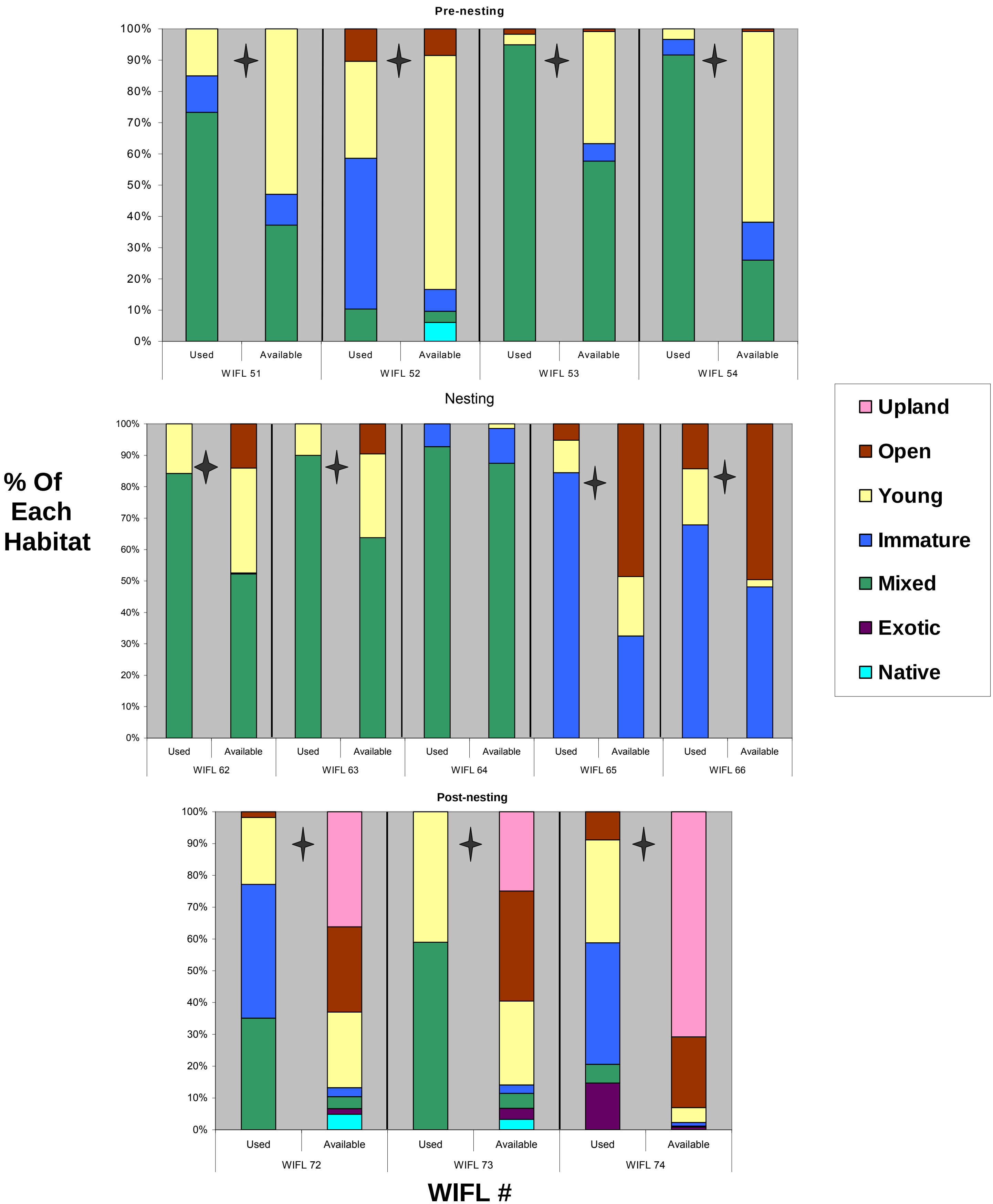


Figure 10: The percentage of used versus available habitat for each flycatcher, grouped by breeding status. Star denotes significant differences in the proportion of habitats used versus available.

DISCUSSION

Home Range and Movement Patterns

Home range is an important biological estimator of the area needed by an individual to succeed in life (i.e., feeding, securing a mate, breeding, etc.). For a neotropical migrant such as the Willow Flycatcher, the area needed in a lifetime includes breeding and wintering grounds, and stopover areas. Even though the scope of this study is limited to the breeding grounds, it is still difficult to define a breeding ground home range due to a lack of consensus on how to define, produce, and interpret home range estimates. Home range has been defined traditionally as "that area traversed by the individual in its normal activities of food gathering, mating and caring for young" (Burt 1943, p.351). However, it is not clear to what extent this definition could apply to early arrival movements, long-distance movements within the season, long-distance movements with fledglings, and post-breeding movements. Presumably some of these movements are important for the success of the individual, but all may not be. Because of difficulty in interpreting the importance of each movement, many studies have adopted a more objective definition. This definition, most often utilizing kernel estimates, defines a home range as "the extent of area with a defined probability of occurrence of an animal during a specified time period" (Kernohan et al. 2001, p 126). The assumption is that the area in which an individual has a high probability of occurrences must be important for its overall success.

For this study, we adopted the probability of occurrence method and defined home range as the area in which a bird should occur 95% of the time during the period that we tracked them. We also calculated the minimum convex polygon, using 95% of locations, for comparison with other studies. With small home range sizes less than one hectare, the two methods showed very similar results, with kernels estimating slightly larger areas. The real distinction between the two methods is apparent when birds have a large home range or use particular areas more frequently than other areas. In these cases, the kernel method more accurately represents what the bird was doing; a MCP describes the entire area that the bird used, while a kernel weights more heavily higher use areas that are probably more important to the bird.

Overall, flycatcher home ranges varied from 0.15 to 360 ha (using 95% kernel; 0.13-178.61 ha using MCP). The variability was due to individual variation, time of season, and breeding status. Adult males tracked early and late in the breeding season tended to have larger territories than nesting birds. In 2003, most home ranges were >1 ha during the pre-nesting season; however, in 2004 three of the four pre-nesting birds had home ranges well under 1 ha for the same time period. In 2004, we found extremely large home ranges, averaging 189.67 ha using 95% kernel ($\bar{x}$ = 123.19 ha using MCP) during the post-nesting season. This highlights some of the challenges facing a study of this kind. We are estimating a parameter that covers several months (May through mid-August) when Willow Flycatchers are on their breeding grounds, while tracking individuals for just a fraction of that time (typically three weeks). In essence, we are developing a static estimate for a dynamic parameter. Given what we observed by tracking individuals at differing stages of the breeding season, it appears that the smaller home ranges of active breeders are underestimates of an individual's home range throughout the season.

The mean home range size ($\bar{x}$ = 0.23 ha using 95% kernel, and $\bar{x}$ = 0.20 using MCP) of nesting-territorial flycatchers tracked in 2004 is not statistically different from those in 2003 and is similar to the low end of territory sizes published in other studies of the Willow Flycatcher from across the U.S. Past researchers estimated average Willow Flycatcher territory sizes at 0.3 ha (Flett and Sanders 1987), 0.4 ha (Prescott 1986), 0.7 ha (Walkinshaw 1966), 1.72 ha (Eckhardt 1979), and 1.1 to 1.8 ha (Stein 1958). These traditional estimates are from individuals mapped throughout the season, and thus reflect a greater time frame than the three-week lifespan of the transmitters. However, the home ranges of our pre- and post-nesters tended to encompass a larger area than recorded in the literature. In general, home range estimates derived from telemetry can be considerably larger than those derived from mapping song perches (Hanski and Haila 1988).

While home range sizes in the nesting season were small, we observed long distance movements and larger home ranges in the pre- and post-nesting seasons. Nesting males had significantly smaller home ranges ($\bar{x}$ = 0.22 ha) than post-nesting males ($\bar{x}$ = 156.43 ha), which has been documented in other bird species (Pechacek 2004). In 2003 and 2004 some pre-nesting flycatchers exhibited long movements to other occupied flycatcher patches where they did not breed during the season they were tracked. These actions could be classified as exploratory behavior or prospecting, defined as movements outside of its territorial or breeding patch to assess habitat for future breeding attempts (Reed et al. 1999). One flycatcher caught at the beginning of the season moved through four occupied habitat patches before settling down into one area. While moving through these patches the bird did not exhibit any obvious territorial behavior, but upon settling into one area territorial behavior was observed. A post-nesting flycatcher made similar movements, it moved over 2 km to occupied habitat patches moving over 500 m in one day. This flycatcher did not settle into one area but moved through many of the flycatcher breeding areas and avoided areas where flycatchers were not breeding. Because flycatcher habitat is successional and changes yearly with growth and river fluctuations, flycatchers may be moving through different habitats to detect these changes.

While some flycatchers may have moved long distances to assess habitat, others were possibly moving to exploit an abundant food resource (Krebs 1971). During the post-nesting period, two birds were observed foraging in habitat with high densities of aquatic insects and/or the tamarisk leafhoppers (*Opsius* sp.; a known flycatcher diet item, see Durst 2004). This was consistent with movements from 2003, where two flycatchers moved to where insect outbreaks occurred. One area had high insect densities in both years and two different flycatchers from 2003 and 2004 moved to this patch during the outbreak. Exploitation of an abundant food resource may be especially important during the post-nesting season when birds are staging for migration.

Three birds made long-distance movements to Shangri-la where they moved through the entire patch. Two were post-nesting birds that moved over 1 km to reach the habitat. The third bird was the fledgling; it moved a distance of over 15 km moving from the mouth of Tonto Creek to the Salt River Inflow. Territorial behavior was never observed. Movements to this particular patch may indicate preferable habitat to avoid predators and stage for migration (Vega Rivera et al. 2003). How important these movements are to lifetime productivity is an important question to address in future research.

Not only did home ranges vary in size, they could also be classified into several different types. We observed both contiguous and non-contiguous home ranges. Contiguous home ranges were compact and tended to be the smallest, and were typical of actively nesting males. Non-contiguous home ranges were composed of a core area and one or more additional distinct and geographically separated areas where at least several detections occurred. Non-contiguous home ranges were typical for males tracked early and late in the breeding season and three types were documented. The first type occurred when a flycatcher had a core area in which it spent the majority of its time, but visited other, non-contiguous areas. This was seen with two post-nesters who moved back and forth among many patches. The second type was observed for one post-nesting bird, which made successional movements; making one long movement to a new area, staying in that location for a number of days, and then moving to a new area. This type of home range could possibly be a post-breeding dispersal movement. The final type was observed in a pre-nesting flycatcher that moved through many breeding sites before settling into its core area. Possibly, this bird was exploring multiple habitat patches to look for a preferred patch or territory. All post-nesting birds made similar movements from their capture locations.

Fledgling and Female Movement

The telemetered fledgling provided insight into juvenile flycatcher biology, including dispersal, age at independence, and habitat use. The fledgling made longer distance movements than any other telemetered adult in either year of this study. The fledgling made at least two dispersal movements, defined here as a movement of over 500 m away from the natal grounds. The first occurred when the fledgling moved 1.5 km away from its family group and presumed natal site and the second when the bird flew over 24 km in one day (it was detected on the Tonto Creek Inflow side of Roosevelt Lake at 06:00 AM and then at Shangri-la on the Salt River Inflow at 10:00 AM on the same day, July 30th). This is the longest movement observed for any Southwestern Willow Flycatcher fledgling (*M. Whitfield, pers. comm.)*. Dispersal, age at independence, and habitat use for flycatcher fledglings is very poorly documented, but can be studied via telemetry. Information gathered from telemetry studies of juveniles are especially important in understanding factors that could possibly limit first-year survival rates and what habitat types are necessary for independent juveniles. In other species, habitat use for independent juvenile birds is significantly different from adult breeding habitat (Anders et al.1998). Further research on juvenile bird movements and habitat use is warranted based on the information gleaned from this single fledgling.

The telemetered female's movements were tied to the location of her fledgling, rarely moving any farther than 80 m from her young. This suggests that female movements are more closely tied to the fledglings than post-nesting males, which moved frequently from their nesting habitat. This female exhibited aggressive behavior when a tracker approached her territory, although this aggressive behavior is not observed in all post-nesting females. The adults that were feeding the telemetered fledgling rarely vocalized when a tracker approached the family group. The telemetered female was tracked just after post-fledgling, while the telemetered fledgling was tracked one to two weeks post-fledgling, suggesting that this aggressive behavior of females may subside as the fledglings mature and become more mobile and better able to escape predation. When young first leave the nest they are difficult to detect because of their small size and their ability to stay still when an observer is close. However, the telemetered female's fledgling was easy to detect based on the female's aggressive behavior. Therefore, for future research on juvenile movements and habitat use it will be important to track both females and fledglings to understand pre- and post- independent movements and habitat use.

Habitat Use

Overall, habitat use provides an understanding of which habitats are important to an individual and a species. Habitat use by flycatchers has been measured traditionally as the area around the nest or within a territory, usually delineated using song perch locations. Our ability to use telemetry to determine which habitats flycatchers are occurring in has allowed us to more accurately assess habitat use, especially the use of areas in which flycatchers would have been difficult to detect via other means.

Flycatchers showed a preference for mixed mature habitat. Fifty-three percent of all detections in 2004 were in mixed mature habitat, a result consistent with 2003, when 52% of locations were in similar habitat (Cardinal and Paxton 2004). This pattern suggests a preference for mixed habitat in flycatcher home ranges at Roosevelt Lake. The second most used habitat was immature vegetation, which is commonly made up of both willow and saltcedar, yet younger and smaller than mixed mature patches. Between 2003 and 2004 the use of immature habitat increased from 4% to 25%, and availability of this habitat increased as well, suggesting flycatchers are moving to this mixed younger habitat as it becomes available.

Willow Flycatchers nest most frequently in mature riparian habitat, but anecdotal observations indicated that they might use other habitat types during the course of the breeding season (Paxton et al. 2003, USGS *unpub. data*). Results from this study show that adult male flycatchers at Roosevelt Lake are using multiple vegetation types, although mature mixed riparian vegetation is the most commonly used habitat. Unlike Willow Flycatchers studied at Fish Creek, Utah (Bakian and Paxton 2004), no flycatchers at Roosevelt Lake were observed using upland habitat. This difference may be due to the greater distance from nesting areas to the uplands at Roosevelt Lake, the much greater extent of riparian habitat available at Roosevelt Lake, and/or it may be that northern Utah upland habitat is more attractive to flycatchers than the upper Sonoran vegetation surrounding the riparian habitat at Roosevelt Lake.

The value of the non-nesting, non-mature riparian habitats used by the flycatcher are difficult to quantify. The telemetered males rarely vocalized outside of core territories, and it was often difficult to determine the exact behavior of individuals using these younger habitats. However, we documented foraging in the younger habitat on numerous cases, and therefore the surrounding non-nesting vegetation may provide an important supplemental food base for flycatchers breeding in the mature patches. Also, in 2004 two telemetered flycatchers and approximately 45 territorial birds were documented nesting or exhibiting territorial behavior in immature habitat on both sides of the lake (Newell et al. 2004). Possibly, the younger habitat was too young for breeding flycatchers until this year and has reached maturity suitable for flycatcher breeding. Documenting productivity in this younger habitat will be important to quantify habitat quality and its importance to breeding birds (Van Horne 1983). This younger habitat also provides a matrix of vegetation surrounding and connecting the mature riparian vegetation, which may facilitate movements and provide safety and resources as flycatchers move around the breeding site.

An important caveat of the analysis of habitat use versus availability is that the proportion of habitat available is a measure derived by the researcher, which certainly differs to some unknown degree from what the flycatchers consider available habitat. Given the high mobility of the flycatchers, the long distances traveled by some of the birds we monitored, and use of multiple habitats by all individuals, most habitats are probably available to them. Our estimates of available habitat were conservative, based on the observed movements of each individual, and certainly do not include all the area used by the flycatchers over the course of the breeding season. Furthermore, the relative importance of different habitat types to flycatchers may vary over time (both seasonally and yearly) and among sites, affecting observed home ranges and movement patterns.

Future Research

Although this study has provided valuable information on unknown or poorly understood aspects of the flycatcher's ecology and biology, more work is needed. We suggest at least one additional year of tracking that focuses on floaters at Roosevelt Lake, to gather more information on spatial behavior and habitat preferences. Also, valuable information could be gained by studying fledglings and females to look at family movements and fledgling dispersal patterns and habitat use. Finally, we recommend that this work should be replicated at other breeding sites to understand how the interaction of flycatchers with their environment may vary across the breeding range.

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