

# **Movement Patterns of Brown-headed Cowbirds in Relation to Impacts on Southwestern Willow Flycatchers**

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## **Movement Patterns of Brown-headed Cowbirds in Relation to Impacts on Southwestern Willow Flycatchers**

### **Introduction**

Brown-headed cowbirds are nest parasites, laying their eggs in the nests of "host" species and then leaving the host to care for the cowbird young. Because the young cowbird is large and grows quickly, it may monopolize the food brought by the host parents, to the detriment of the host's own young. Health and survival of the host's own young is sometimes reduced to the point where none of the host young survive (McGeen 1972; Mayfield 1977a; Brittingham and Temple 1983). Prior to the 1800's, brown-headed cowbirds were primarily limited in range to the open grasslands of central North America, where they were associated with the great bison herds that once roamed the plains. With European settlement of the continent, cowbirds have become much more widespread throughout the United States and southern Canada (Rothstein et al. 1980, Verner and Ritter 1983, Airola 1986, Robinson et al. 1993). They appear to have had adverse effects on native bird species in some of the areas that they have recently invaded, particularly in riparian habitats.

Because breeding bird populations in riparian areas are concentrated in small areas at high densities, cowbird nest parasitism can affect a major part of the breeding bird community in the area. In fact, declines in many neotropical migrant bird populations over the past 50 years have been linked to cowbirds (Laymon 1987), and cowbirds are considered one of the major threats to neotropical migrants on the breeding grounds (Robinson et al. 1993). Gaines (1974) demonstrated that virtually all of the riparian songbird species that have declined in the Sacramento Valley of California during this century are heavily parasitized by cowbirds. In Arizona, significant numbers of cowbirds and associated high levels of cowbird nest parasitism have been documented virtually throughout the state (Phillips et al. 1964, Drost 1996) on a wide variety of songbirds. Some of the most vulnerable and negatively affected host species include the Bell's Vireo (*Vireo bellii*), Yellow Warbler (*Dendroica petechia*), Blue Grosbeak (*Guiraca caerulea*), Common Yellowthroat (*Geothlypis trichas*), and the federal and state of Arizona Endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*: Phillips et al. 1964, Harris 1991, U. S. Fish and Wildlife Service 1993, Brown 1994, Drost 1996, Sogge 1995a and 1995b). The parasitism problem is so extreme that local breeding populations of the willow flycatcher in Arizona have experienced 100 percent nest parasitism in some years, resulting in a total loss of reproductive effort during a year (Sogge et al. 1995).

Other studies have found characteristic daily movement patterns among cowbirds. In early mornings, they spend time in host-rich riparian areas where they search for and parasitize other bird's nests. Later in the morning, they fly to and gather at areas of concentrated food resources, where they often remain for the rest of the day. These concentration sites may be associated with human-related activities such as livestock, camp grounds, or in some cases, residence areas with bird feeders (Rothstein et al. 1980 and 1984, Drost 1996, Johnson and Sogge 1995). Cowbirds are seldom seen foraging in riparian areas, but instead rely heavily upon the presence of concentrated food resources, and will "commute" 7 miles or more between riparian "parasitism" areas and feeding concentration areas (Rothstein et al. 1984).

### **The Verde Valley and Southwestern Willow Flycatchers**

The Verde River, which winds through the Verde Valley of north-central Arizona, is bordered in many areas by dense riparian vegetation, which provides excellent habitat for many breeding songbirds (Sutton 1954, Carothers and Johnson 1970, Story and Burbridge 1974, USDA Forest Service 1981), including the Southwestern Willow Flycatcher (Muiznieks et al. 1994, Sferra et al. 1997, Sogge 1995a). Adjacent to and surrounding this valuable riparian resource is a complex matrix of agricultural and urban land uses, ranging from large- and small-scale ranching and farming to varied densities of commercial and residential properties. The Verde Valley is one of the fastest growing regions of the state, and the increased population and conversion of land to higher density residential properties is expected to continue in the foreseeable future. These land use changes are certain to have effects on many of the natural resources of the region.

One of the potential effects associated with urbanization of the Verde Valley is a change in the nature, location, and number of cowbird foraging and concentration centers. Because cowbirds in Arizona rely on these areas, such a change could in turn affect the number and distribution of cowbirds in the area. Although the abundance and negative effects of cowbirds have been documented in the riparian areas of the Verde Valley (Muiznieks et al. 1994, Sogge 1995b), no one has investigated the movements of cowbirds to determine the locations of their concentration sites, and how far they travel to parasitize the nests of other birds. In fact, this type of research has never been conducted anywhere in Arizona. Yet an understanding of the nature and location of cowbird foraging concentrations, and determination of how widely cowbirds range in a particular situation is essential information for evaluating the effects of changing land uses on cowbird impacts on native nesting birds. It can also serve as the foundation for effective cowbird management and control associated with threatened and endangered bird conservation efforts. Such cowbird control has been proven effective in many endangered bird conservation programs, including the Southwestern Willow Flycatcher (Mayfield 1977b, Beezley and Rieger 1987, Laymon 1987, Bolsinger and Hayden 1992).

## **This study**

The Verde Valley is an ideal system in which to study cowbird movements in Arizona, to evaluate how cowbirds use and respond to different land use practices, and to learn how these factors relate to nest parasitism of riparian breeding birds. Cowbirds are common in this area, and their negative effects on native birds have been documented. The valley also contains two small breeding populations of southwestern willow flycatchers, one near Clarkdale and the other near Camp Verde, which are monitored for cowbird nest parasitism by the Arizona Game and Fish Department and other researchers. The variety of local land uses provides a diverse array of potential cowbird concentration sites, all within a relative short distance from willow flycatcher breeding sites and other riparian areas. The lessons that can be learned here have implications beyond the Verde Valley, as there are many similar riparian areas in Arizona that are facing similar pressures of urbanization. Data from the Verde Valley will provide a sound scientific basis for projecting potential effects, and for developing conservation and management programs for the southwestern willow flycatcher and other neotropical migratory birds.

## **Objectives**

Specific objectives of this project were to:

- 1) use a combination of surveys and counts of cowbird flocks, and tracking of radio-tagged birds, to document the nature and location of cowbird concentration areas in the Verde Valley;
- 2) use radiotelemetry techniques to monitor the movements of cowbirds, emphasizing the distance that individual cowbirds move between feeding areas and nest parasitism areas; and
- 3) relate cowbird movements to particular land use practices, and evaluate cowbird movement patterns in relation to potential management alternatives for conservation of the southwestern willow flycatcher and other endangered and sensitive riparian birds in Arizona.

## **Methods**

### **General surveys**

Extensive searches were conducted in the vicinity of the Clarkdale and Camp Verde sites to evaluate Brown-headed Cowbird distribution and concentration points, and to determine factors related to these concentrations. We broadly surveyed these areas by vehicle and on foot, emphasizing public lands (including Coconino and Prescott National Forests, Dead Horse State Park, Tuzigoot National

Monument, and Tavaschi Marsh, managed by Arizona Game and Fish Department). We noted location and abundance of cowbirds seen, and conditions which appeared to be attracting the birds to that area. We also solicited observations from local Arizona Game and Fish staff, National Park Service staff, U.S. Forest Service employees, and members of the general public (particularly through the local chapter of the Audubon Society). Cowbird counts in specific areas of interest were conducted on a regular basis using survey methods adapted from Johnson and Sogge (1995).

### **Trapping**

Cowbirds were trapped in close proximity to known southwestern willow flycatcher breeding sites along the Verde River and in Tavaschi Marsh. We used modified Scandinavian crow traps, which are large, drop-in cage traps and have a very low potential for harming any of the birds caught (e.g. Bub 1978). The traps were placed in discreet locations away from major public use areas. However, since Tavaschi Marsh attracts many hikers, bird-watchers, and other recreational users, we posted informational signs describing the study, and noting that none of the birds trapped are being harmed. The signs also acknowledged Arizona Game and Fish Heritage Grant funding for the project, and described the conservation goals of the project.

Traps were baited with millet, and water was provided from at least two one-gallon continuous waterers. An important attraction of this kind of trap (particularly for flocking bird like cowbirds) is the presence of other birds already in the trap, so we also place four to six cowbirds in the cage portion of the trap at the beginning of trapping (these "bait" birds were captured in potter traps at cowbird feeding areas). Birds enter the trap by dropping through a small slot in one of the top panels of the trap. Once inside, they cannot fly back up through the narrow slot, and so are trapped.

### **Marking / Banding**

All cowbirds trapped were banded with numbered National Biological Service aluminum leg bands and fitted with colored plastic bands, color-coded by trapping station. Adult birds were given a unique combination of up to three color bands, so that the individual bird could be identified, as well as its original capture location. Juvenile birds were given a single, trap-site color band so that we could identify their original capture location. Since we were interested primarily in the movements and nest-searching activities of adult birds, it was not necessary to give juveniles unique color combinations.

### **Radiotelemetry**

During the cowbird and songbird nesting season (May through July), we affixed radiotransmitters to the backs of captured female cowbirds. We chose to track female birds it is their movements and activity in laying eggs in host bird nests that are of the most direct management concern. We used model BD-2G

transmitters (Holohill Systems Ltd., Ontario, Canada), which are small enough (1.4 g) that they should have no negative effect on the cowbirds. Transmitters were attached to the center of the back below the scapulae, using cyanoacrylate adhesive ("SuperGlue"). The feathers of the back were trimmed to the skin, in an area slightly larger than the transmitter package. The transmitters used have a nominal battery life of six to eight weeks. In general, we wait until we had several cowbirds trapped before affixing transmitters, so that we would have multiple radio-telemetered "targets" at any one time.

### **Tracking**

When radiotagged birds were abroad, we generally tracked them throughout the day, at least five days per week. Initially, observers tracked birds throughout the daylight hours. As we became familiar with the birds' activity patterns and movements, we scaled back this schedule somewhat; for example, we did not repeatedly check locations of birds in the heat of the middle of the day, when they had moved to a roost and become inactive. However, we maintained a schedule of checking the birds at intervals throughout the day, and following them continuously during periods when they were active.

We tracked the cowbirds from roads throughout the area, and from selected overlook vantage points. Whenever possible, we homed in on radio fixes, to get a visual confirmation of the bird's location, and to record its activity at the time. This was not always possible, as when a bird was in dense vegetation, or on private land. For all radiotelemetry locations, we noted individual identification, time, and actual or estimated location of the bird. We also noted activity of the bird, as well as habitat type. Locations were either plotted directly on copies of 1:24,000 scale maps, or were noted in relation to prominent landmarks and then transferred to maps later. Sequential locations were tabulated for each radiotagged individual.

### **Observation**

Detailed notes were recorded on the activity of radiotagged birds. This included time of activity, type of behavior noted, interactions with other cowbirds and other bird species (particularly potential host species), and observed movements. We also recorded numbers, location, time, and activity of any unmarked cowbirds encountered during the course of tracking.

### **Analysis**

#### **Behavior / habitat use**

Cowbird numbers and seasonal activity patterns were recorded in a general way. We did not attempt precise population estimates. Instead, during surveys in areas throughout the Verde Valley, we noted such things as: time first cowbirds were seen in the spring; any concentration areas that were

encountered, including number of cowbirds present; and time of nature of cowbird activity. Activity of cowbirds seen during surveys and in radiotelemetry tracking was categorized as foraging; resting; moving (flying long distances); singing / displaying; prospecting for nests (typical behavior consists of solitary females perched at the top of a prominent vantage point, surveying the surrounding area); or unknown (for birds not seen). Habitat at each site was categorized into major habitat types in the area, including woodland, desert scrub, riparian, marsh, irrigated pasture, dry field, and urban/suburban. Activity type in different habitats and at different periods of the day was summarized and evaluated using a non-parametric test of independence.

### **Trapping results**

Traps were operated continuously after they were opened in late spring until they were closed in mid- to late summer. We tabulated capture rates per week for adult males, adult females, and juveniles (young of the year). Capture data, including date, location, sex, age, morphological measurements, band number, band color combination, and transmitter number (if any), were entered into a separate database.

### **Movement**

Cowbirds typically fly some distance between roosting and feeding and nest-searching areas. From a management standpoint, the most important question is how far cowbirds may travel to reach a nest-parasitizing area. Because the time pattern of movements is also of interest, we summarized the sequential movements of each radio-tagged cowbird, then calculated average distance moved, maximum distance per single movement, and maximum distance covered among all movements (i.e. between the two farthest points the bird occupied)<sup>1</sup>. We also reviewed the pattern of movements and typical behaviors (e.g. to see whether the same routes are traveled repeatedly; and whether the same feeding areas and nesting areas are visited repeatedly, or a variety of areas are used). We tabulated different measures of cowbird movement to depict the approximate "area of influence" of cowbirds around willow flycatcher nest sites - i.e. the area within which cowbirds may impact flycatcher nesting (this may be calculated, for example, as the mean maximum distance cowbirds travel between foraging areas and nest parasitism areas).

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<sup>1</sup> Because cowbirds travel between separate, sometimes distant areas used for different activities (feeding, roosting, nest-searching), traditional models of home range do not fit well, and we did not attempt to calculate an overall "home range."

## Results

### Fieldwork

Field work began in spring 1996. We conducted surveys for cowbirds in the Tavasci Marsh - Verde River - Cottonwood - Clarkdale - Cornville area, for cowbird occurrence, concentration areas, and activity. We began using a variety of techniques to capture and mark cowbirds, including mist nets, potter traps, and the large cowbird traps. Mist nets and potter traps were ineffective in the areas we had access to, so after our preliminary efforts, we concentrated on the large traps for capturing cowbirds.

Traps were set out at three sites in 1996: site 1 (CL) was along the margin of the Clarkdale wastewater treatment plant, adjacent to the Verde River just upstream from the Tuzigoot bridge over the Verde River; site 2 (TM1) was along the west side of the southern end of Tavasci Marsh, east of the Tuzigoot National Monument visitor center; site 3 (TM3) was on the east side of the marsh, east of site 2 and north of the Verde River, near the road linking the marsh to Dead Horse Ranch State Park. Trapping began on 28 May in 1996, and continued through the end of July.

Traps were set out at two sites in 1997: site 1 was TM1, described above; and site 2 (TM2) was at the northwest end of Tavasci Marsh, south of the east end of Peck's Lake. Trapping in 1997 began in mid-May, and continued through the end of July. Trapping results are discussed in the section on Trapping, below.

Because of problems with late arrival of funds, combined with a lost shipment of equipment, we were not able to begin radiotelemetry in 1996. We were able to collect some information on movement, concentration areas, and activity from color-banded birds and general observation of cowbirds during the spring and summer. We began attaching radiotransmitters to birds in spring of 1997, and collected movement, habitat, and activity data from telemetry of birds marked in spring and summer of that year.

### Seasonal pattern

Based on our observations from 1995 (when we conducted preliminary observation, prior to this study) through the present, we have the following general timeline for Brown-Headed Cowbirds in and around Tavasci Marsh: cowbirds return to Tavasci Marsh in the first or second week of April, and begin nest-searching almost immediately. We have noted nest-searching behavior as early as April 10. Most of the breeding species of the marsh area have begun nesting by this time, with a few (such as Red-winged Blackbird) beginning nesting in the next few weeks. A few species, including Blue Grosbeak and Willow Flycatcher, do not arrive for a few weeks - at the beginning of May or even later.

First young-of-year cowbirds are seen by the middle of June, and we began catching them in the large traps by the last week of June. Large numbers of juveniles are showing up in the traps by the middle of July.

There is a shift in the behavior of adult birds beginning around the middle of July. Less of the day is spent nest-searching in the marsh, and foraging activity spreads out to surrounding suburban areas. The apparent pattern is: adult birds come to the marsh early in the morning to nest search, then when the singing and activity die down in mid-morning they disperse to foraging areas, predominantly to feeders in the town of Cottonwood. This behavioral shift to use of suburban areas was observed in both years, and is described further under Activity, below.

In the latter of half of July, the marsh is becoming relatively quiet. Common Yellowthroat, Blue Grosbeak, and Yellow-breasted Chat are still singing, but little else. By the beginning of August, cowbird numbers in the marsh have decreased noticeably. Some larger cowbirds (presumably northern migrants) are seen in the marsh and captured in our traps. Cowbirds in the area are observed foraging earlier (e.g. 9 a.m.), primarily in pastures and suburban areas. Most of the local cowbirds have dispersed from the marsh area by the middle of August.

At least some of the cowbirds that summer in Tavasci Marsh remain in the area through the winter. Over three winters, we have recorded cowbirds through the middle of winter at sites around town of Cottonwood, including predictable small numbers in the parking lot of the Wal-Mart shopping complex in central Cottonwood. In mid- and late November 1997, we noted three birds that we had banded in Tavasci Marsh (two at the beginning of June and one at the beginning of July) in this Wal-Mart parking lot, confirming that at least some of the cowbirds spending the winter in the area are local residents.

### **Trapping**

We set out large cowbird traps at four different locations over the course of this study: three in and around Tavasci Marsh, and one at the Clarkdale wastewater treatment plant (see descriptions above). Trap success varied markedly among these different sites (Table 1). Traps TM1 and TM2 captured the most birds, while TM3 and CL each captured 10 or fewer. TM1 and TM2 were both located in open areas with a few small shrubs nearby. The Clarkdale trap (CL) was located adjacent to a riparian woodlot, facing a wastewater pond and the Verde River beyond. Trap TM3 was adjacent to a grove of large cottonwoods, open on one side to short grass and mesquite.

**Table 1.** Trap data for large cowbird traps set in the vicinity of Tavasci Marsh in 1996 and 1997.

Trap	Dates	Trap-days	number of cowbirds
CL	28 May - 25 July 1996	85	9
TM1	23 June - 28 July 1996	35	55
	16 May - 15 July 1997	60	37
TM2	11 June - 15 July 1997	34	38
TM3	28 June - 25 July 1996	27	10

Abbreviations are:

CL = Clarkdale sewage treatment plant;

TM1 = Tavasci Marsh 1, southwest side of marsh, east of Tuzigoot NM visitor center;

TM2 = north end of marsh, south of Peck's Lake;

TM3 = southeast side of marsh, near road to Dead Horse Ranch SP

Over the course of two seasons' trapping, we captured a total of 149 different cowbirds (this does not include rather numerous recaptures). A few of the May and August birds are believed to have been migrants passing through the area, but most of the birds trapped were residents. Of the total caught, 56 were adult male cowbirds, 45 were adult females, and 58 were hatch-year birds. All of these birds were banded with USGS numbered metal bands. Adult birds also received a unique combination of up to three color bands. Juvenile birds (hatched in the current year) were given a single color band indicating the trap they were initially caught in. Appendix 1 lists banding information for all of the Cowbirds captured.

### **Radiotransmitters**

Most of our information on cowbird movements is from birds fitted with radiotransmitters and tracked over a period of up to one month. We glued transmitters directly to the backs of adult female cowbirds, after first clipping and removing the feathers of the back, just below the bird's scapulae, over an area slightly larger than the transmitter unit. The transmitter itself was first glued to a small "pad" of denim patch material (approximately the size of the transmitter), then this pad was glued to the bare patch on the back of the bird.

Initially, the birds were able to remove the transmitter packages rather quickly, and we had to experiment with a variety of different glues and attachment procedures. The combination that worked best was first using a cotton swab dipped in acetone to wipe the area of the bird's back to remove skin oils, then using a thick preparation of cyanoacrylate glue (sold commercially as fingernail glue). We

held the transmitter package in place for one - two minutes, until the glue was fully dried. After we began using this technique, we had no further problems with lost transmitters.

Nominal battery life of the transmitters we used was four - six weeks, and we had several birds that we followed over this span of time. On the other hand, we also a radio that was weak at the outset, and so was not used. We also had three birds that we lost contact with after only one or two days; we do not know if this was due to transmitter failure or if the birds simply left the area (two of these were birds marked at the beginning of August, so they may have been transient birds that simply moved on out of the area). In any case, we did not use data from birds that we did not have at least five good days of tracking for, except for general comparison, and corroboration of patterns seen in longer-term tracking (Appendix 2 summarizes information on all of the birds fitted with transmitters).

### **Movements**

There were three conspicuous trends revealed by the radio-tracking data. These were:

- 1) the short distances moved by the cowbirds, even when moving between areas of major activity (foraging, nest-searching, roosting);
- 2) regular, repeated use of particular areas. This was true both of individual birds returning to the same spot time after time, and also true of different birds using the same areas;
- 3) movements were largely confined to the immediate area of Tavasci Marsh and adjacent sections of the Verde River during the first half of the breeding season (May - June; see Figure 1).

Table 2 outlines the observed movements and behavior of one bird over a two-day period, as an example, and illustrates the three patterns listed above.

A fourth conspicuous trend in the movement data was a shift, beginning about the middle of July, to birds moving to suburban areas of Clarkdale and Cottonwood, outside of Tavasci Marsh and the adjacent Verde River riparian area (as opposed to all activities being concentrated in the marsh area; see Figure 2). Almost no use of suburban backyards, bird feeders, large lawn areas and associated hedgerows was seen in May and June, but by the latter part of July, up to half of all radiotelemetry locations were from these suburban areas. In most cases, these movements were much farther than the early-season movements within the Tavasci Marsh / Verde River area.

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**Table 2.** The following notes describe the movements of one radio-tagged bird, # 742, over a two-day period in the Tavasci Marsh area of central Arizona in 1997 (refer to Figure 1 for general orientation to the area)

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22 June, 828: located opposite TM2 in willow/mesquite/russian olive (east, towards Shea Spring)

22 June, 904: still in general area of Shea Spring

22 June, 916: moved down the marsh - 400m SSE of Shea Spring

22 June, 932: 500m SSE Shea Spring, near a dead cottonwood near the marsh platform

22 June, 935: flew up into adjacent tree

22 June, 956: Cottonwood Grove adjacent to new construction (W of TM2)

22 June, 1010: trap side of marsh (TM2)

22 June, 1030: Shea Spring

22 June, 1558: Shea Spring

23 June, 720: Marsh crossing (ca. 850 m S of Shea Spring)

23 June, 940: Shea Spring - directly across (to NE) of marsh from TM2

23 June, 1000: Due E of TM2 across marsh in mesquite thicket

23 June, 1036: very close to previous position- very dense mesquite

23 June, 1430: Shea Spring, close to previous position- very dense mesquite

23 June, 1610: near TM2

24 June, 1410: still across marsh

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### **Movement distance**

During the course of intensive radiotelemetry tracking, cowbirds were frequently recorded moving very short distances during the course of normal activities, from a few meters, to 100 - 200 m. We were primarily interested in the distance cowbirds may move to and from nest-parasitizing areas within Tavasci Marsh and the Verde River riparian area, so we concentrated our analysis on longer-distance movements. We broke this down into three components: 1) the average distance moved (not counting short movements of 200m or less); 2) the range of what we knew or thought to be single movements (shortest and longest); and 3) the farthest point-to-point distance taking into account all of the points occupied by a particular individual (Table 3). The overall average distance moved, considering all birds over the entire season, was 1.48 +/- 1.05 (s.d.) km.

Distance moved ranged from very short movements, up to movements of 4 - 5 km. Maximum distance across a single bird's range varied from 1.4 km to 5.2 km. Movement distances varied among individual birds, both in average distance moved and maximum distance moved. The most conspicuous difference, however, was between early (May - June) and late season (July - August) movements. Average distance of movements recorded in May and June ( $0.91 \pm 0.77$  km) was significantly less than average distance recorded in July and August ( $1.76 \pm 1.09$  km;  $P < 0.05$ , ANOVA). As noted, this difference is related to birds expanding their range during this time to include suburban areas of Cottonwood and Clarkdale (as a general example of this, compare the distances for birds # 742 through 767 in Table 3, with those for # 775 through 789).

**Table 3.** Movement distance of radio-marked Brown-headed Cowbirds in the vicinity of Tavasci Marsh and Tuzigoot National Monument in central Arizona. Only longer-distance movements are included (e.g. movements of 200m or less are not tabulated). "Fixes" is the number of locations recorded for that particular bird. Maximum distance is the distance between the furthest two points occupied by the bird.

Bird	Dates	Movement (km) mean $\pm$ s.d. (range)	Fixes	Maximum distance (km)
742	18 June - 12 July	1.1+0.48 (0.4 - 2.1)	48	2.1
746	20 - 24 June	0.79+0.47 (0.3 - 1.4)	19	1.4
747	23 June - 3 July	0.94+0.57 (0.6 - 1.6)	15	3.8
766	21 May - 13 June	0.98+0.60 (0.2 - 1.8)	32	2.3
767	5 June - 16 July	0.84+0.53 (0.3 - 1.6)	34	1.7
775	1 - 2 August	0.93+0.65 (0.5 - 2.0)	10	2.0
776	6 July - 21 Aug	1.63+0.86 (0.4 - 4.0)	76	4.4
777	6 - 28 July	1.92+1.0 (0.5 - 4.2)	110	4.3
787	8 - 21 July	2.06+0.99 (0.9 - 3.7)	36	3.0
789	8 - 22 July	2.21+1.44 (0.7 - 4.8)	35	5.2

## Activity patterns

### Daily pattern

Major cowbird activities show a distinct time pattern over the course of the day (Table 4). Nest-searching was the most common behavior during the morning hours, accounting for nearly half of all observations between 6:00 and 11:00 am. Some nest-searching was seen throughout the remainder of the day (particularly in late afternoon), but at a much-reduced rate. Roosting was the predominant activity through the afternoon, accounting for over half of all observations and peaking at 64% of observed behavior during the early afternoon hours. Foraging was relatively evenly distributed throughout the day.

**Table 4.** Timing of major Brown-headed Cowbird activities throughout the day, based on observations during radiotelemetry tracking and during general surveys. For each column, the numbers show the percentage of observations of each behavior for that time period. "n" is the sample size (number of observations) for the time period.

	6-9 am	9-11	11-1	1-3 pm	3-5	5-8 pm
Foraging	29 %	22	35	23	36	27
Nest-searching	49	48	14	14	12	23
Roosting	22	30	51	64	52	50
n	59	93	43	22	42	22

### Relation to habitat and land use

We divided observed cowbird activity up into three main categories: foraging, nest-searching, and roosting (we also noted "moving" - birds flying from one area to another, but we did not include that category in the following analysis). The three activities differed in relation to habitat (test of independence:  $G=89.18$ ,  $df=8$ ,  $Prob. < 0.001$ ; Figure 3). Cowbirds spent the greatest amount of time foraging in (in order) suburban areas, mesquite thickets, and pasture. Little foraging activity was observed in either the marsh or in riparian woodland. In contrast, nearly half of all nest-searching activity noted was in the marsh, with substantial additional amounts in mesquite and in riparian woodland; very little nest-searching was observed in suburban areas, and none in pasture. Most roosting activity was in mesquite thickets (accounting for half of all observations), followed by trees and shrubs in suburban areas. Little roosting was seen in the marsh or in riparian habitat, and none in pasture.

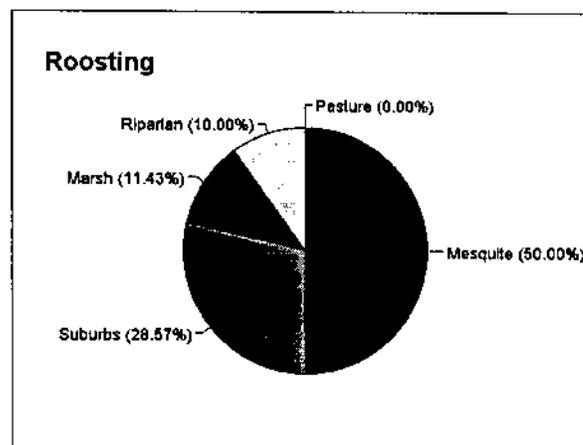
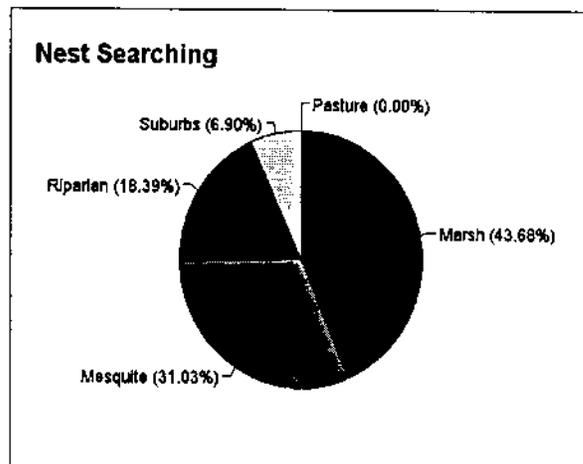
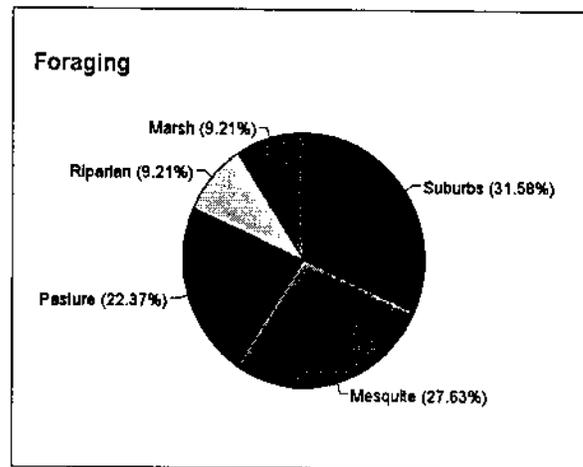


Figure 3. Habitat location of major activities of Brown-headed Cowbirds in the Tavasci Marsh area, 1996 and 1997 seasons. "Suburbs" indicates residential and commercial properties in Clarkdale and Cottonwood. "Pasture" includes both irrigated pasture and dry fields.

Because of the shift in activity observed between early and late season, we compared foraging habitats used over the course of the season (Table 5). During May and June, most foraging (87%) was in native habitats in and around Tavaschi Marsh. Most observations were in mesquite, where the birds were observed eating caterpillars. During July and August, the majority of foraging (80%) had shifted to non-native habitats. This included both pastures and fields, and suburban areas. Most observations of birds in pasture were primarily in irrigated pasture, with or without grazing animals. We had only one observation of foraging in a dry field, and this bird was associated with cattle. In suburban areas (including the yards of private homes, as well as some public and commercial properties), most foraging was at bird feeders.

**Table 5.** Foraging habitats of Brown-headed Cowbirds in the vicinity of Tavaschi Marsh in 1997, based on observations during radiotelemetry tracking and general surveys. Table values are number of observations in each habitat for early season (May - June) and late season (July - August). Abbreviations are MA=Marsh; ME=Mesquite; RI=Riparian; PA=Pasture/field; SU=Suburb (including bird feeders). "n" is sample size (total number of observations).

	MA	ME	RI	PA	SU	n
May-June	4	19	3	1	3	30
July-August	3	2	4	16	21	46
n	7	21	7	17	24	76

## Discussion

### Cowbird seasonal occurrence

Early-nesting bird species escape some of the burden of potential cowbird parasitism, as they already have their first broods in the nest by the time cowbirds arrive and begin nest-searching. The nesting chronology of late-arriving species, including the Southwestern Willow Flycatcher, overlaps more fully with the time cowbirds are active (see Sogge et al. 1997). This puts them at risk of nest parasitism throughout their breeding period.

The peak nest-parasitizing period in the Tavaschi Marsh area is during May and June. Cowbirds begin spending less time in the marsh during the first half of July, and more time in nearby suburban areas. By the second week of August, most cowbirds have left the marsh. We only have a partial

understanding of cowbird dispersal from the area. Numbers are much reduced in the latter part of August. Some of the local birds stay in the area throughout the winter, as evidenced by color-banded birds from Tavasci Marsh being re-sighted in the town of Cottonwood in the middle of winter. However, cowbird numbers in the vicinity during the winter are much lower than during spring and summer, so it appears that the majority of the cowbird population migrates away in the Fall, and returns in the Spring.

### Trapping

The large cowbird traps are the most effective means of capturing cowbirds that we tried in Tavasci Marsh. It is possible to catch small numbers of cowbirds in mist nets in the area, and potter traps should likewise yield some captures in corrals and feedlots. However, neither of these methods capture large numbers of birds, and both are also much more time-intensive than the large cowbird traps which, after initial set-up, can be left and checked on a daily or every-other-day schedule. Particularly during May and June, cowbirds seemed to be very attracted to the traps, and we recaptured many of the birds that we released (including, unfortunately, some of the birds with radiotransmitters - a few "trap-happy" birds had to be excluded from analyses).

Incidental captures of other species were not a serious problem. We captured small numbers of Red-winged Blackbirds and European Starlings. These birds were unharmed and were released back to the marsh. More unusual was an adult Lucy's Warbler, which was also released unharmed. This bird was in the trap with a fledgling cowbird, and we assume she entered the trap to feed the cowbird and was then unable to find her way out.

Over the course of this study, we had traps in four different locations, with different success rates at the different sites (Table 1). The two traps that had the highest success rates, TM1 and TM2, were set in similar areas. Both were in quite open sites, in short grass / bare ground and with woody vegetation limited to low mesquite shrubs to one side of the traps. The other two traps were open on one side, but the other side faced tall trees - a cottonwood grove in the case of trap TM3, and a riparian woodlot in the case of trap CL. We suspect the nearness to tall trees may have limited the capture success of the latter two traps.

Capture rates in the large cowbird traps were highest in May and June, and decreased in July and August. By August, we were capturing few new birds. Numbers of cowbirds in the marsh were decreasing during this time, which may partly explain the reduced capture rate. Increased mobility of the cowbirds at this time may also have contributed, perhaps along with increased alternative food resources. From a potential management standpoint, it is more favorable to have a high capture rate early in the season; maintaining a high capture rate in the mid- and late summer is probably not needed.

We captured numbers of young, first-year cowbirds. During July, 49 out of 105 total captures were Cowbirds hatched in the previous few months. Some of these birds were recently fledged, as evidenced by the presence of down and still-growing flight feathers. We assume, given the timing of the captures (before the beginning of migration) that most or all of these young birds were produced in Tavasci Marsh and the immediate surrounding area.

#### **Loss of transmitters and birds**

Initially, we had some difficulty with birds removing transmitters. All of the transmitters that we placed on birds in the first week were pulled off within 24 hours - some within one hour. After some experimentation, we developed a method that worked well, and we did not have further problems with transmitter loss. We switched to using thick preparations of cyanoacrylate glue advertised as "super-hold." We also glued a small patch of denim cloth to the transmitter, then applied glue to the denim side of the transmitter, and pressed it against the bird's back until the glue was dry.

We lost contact with five radio-marked birds less than a week after their release (see Appendix 2). We believe these birds either left the area, moving out of our tracking range, or that their transmitters failed. We do not think these birds lost their transmitters: during the time period when birds were removing transmitters, we still received clear signals from the detached transmitters from a variety of situations, including on the ground in dense brush. We were able to recover and re-use most of these detached transmitters, by triangulation and careful searching. Since we were easily able to pick up signals from transmitters on the ground, we felt that we could distinguish between a detached transmitter, and a bird that had left the area (or a transmitter that had failed). Three of the birds that were lost were relatively late captures (one on July 19 and two on August 1). Given the pattern and timing of dispersal that we observed among the cowbirds in the area, our "loss" of these birds may simply reflect normal dispersal / migration from the Tavasci Marsh area following the breeding period (or, in the case of the August birds, we may have had migrant birds that continued their movement through and out of the area).

#### **Movements**

One of the primary motivations for this study was to assess the movement distance of Cowbirds in the Verde Valley, in relation to cowbird impacts on nesting birds such as the Southwestern Willow Flycatcher, and with respect to potential management actions to reduce cowbird impacts. Studies have shown that cowbirds typically utilize different areas for feeding, searching for host nests, and roosting, and that they may fly considerable distances between these different activity areas (Rothstein et al. 1984). In the Verde Valley, this has led to interim management guidelines by the U.S. Fish and Wildlife Service regulating activities such as grazing on public lands within a prescribed radius of known Southwestern Willow Flycatcher nesting areas. The distance required by Fish and Wildlife

Service (7 miles) was based on literature values because no data were available for Arizona or the Verde Valley.

In contrast to the pattern seen in some other areas, the cowbirds in the Tavasci Marsh area center all of their activities in the same, small local area. Movement distances are very small, particularly in the early part of the nesting season, when the average of long-distance movements is less than 1 km. The maximum distance across the range of any cowbird that we tracked during the early season was 3.8 km (Table 3). As cowbirds began expanding their range in July and August to include suburban areas of Clarkdale and Cottonwood, the average movement distance increased to 1.8 km, with a maximum distance across the range of 5.2 km.

These travel distances are much shorter than those recorded in other areas. For example, in Illinois and Missouri, Thompson (1993) found average movement distances of 3.6 km between roosting and breeding areas of cowbirds. Studies at Fort Hood, Texas, found average distance from roost to nest-parasitizing areas of 12 km (maximum about 20 km; T. Cook, pers. comm.) Studies along the South Rim area of the Grand Canyon area of northern Arizona found cowbirds traveling as far as 28 km (Drost 1996). These studies all noted geographically separate areas for the main cowbird activities (foraging, nest-searching, roosting) during the nesting period, with cowbirds "commuting" between these areas.

Pattern of movements varied in relation to time of day and in relation to season. Most movements were in the morning hours prior to noon, and in the afternoon after 4 pm, with birds being relatively sedentary during the heat of the midday. As already described, there was a distinct seasonal shift in movement pattern and habitats occupied, with radio-tagged cowbirds expanding their feeding range well out into pastures along the Verde River, and suburbs of Clarkdale and Cottonwood. This shift corresponded to decreased time spent in marsh and riparian habitats, and steadily increasing time spent in pastures, and at backyard bird-feeders, lawns, and other areas the cowbirds frequented in the suburbs (Figure 4).

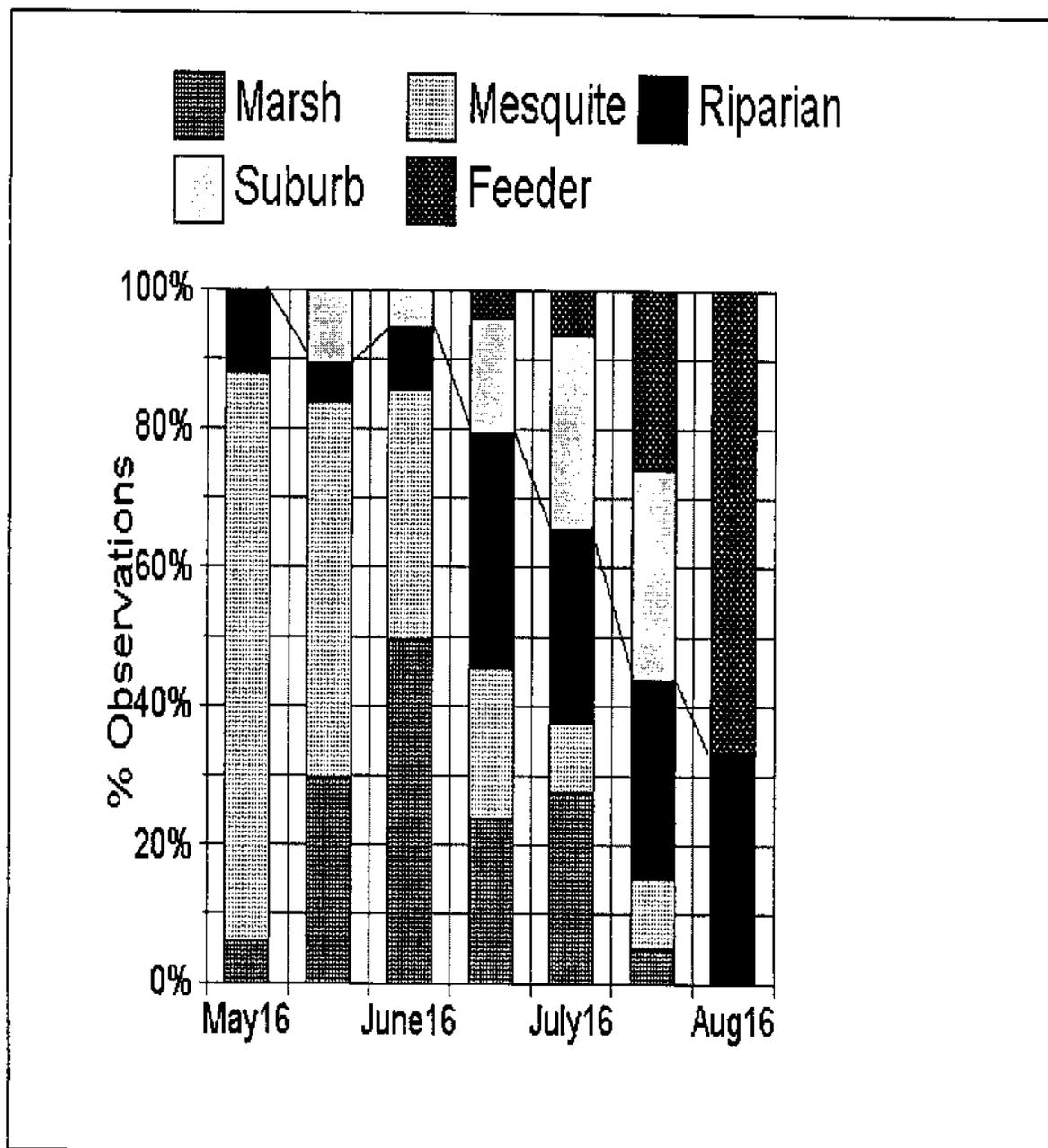


Figure 4. Time spent by Brown-headed Cowbirds in different habitats in the vicinity of Tavasci Marsh and the towns of Clarkdale and Cottonwood, in relation to season. Vertical columns are two-week periods (e.g. "May 16" represents May 16 - May 31). The line connecting the columns shows the decreasing amount of time spent in Marsh / Mesquite / Riparian, and the corresponding increasing amount of time spent in suburbs and at bird feeders.

## Activity

In addition to the short-distance movements recorded for resident cowbirds, another significant finding of this study was that the Tavasci Marsh cowbirds carried out all of their main activities in the same local area, within Tavasci Marsh, and the adjacent Peck's Lake and Verde River riparian areas. This was particularly true during the first half of the season, when foraging, nest-searching, and roosting areas could be essentially side-by-side. As with movements, activity patterns showed seasonal shifts. During the early part of the season, the majority of foraging, nest-searching, and roosting occurred in native habitats within and surrounding Tavasci Marsh (see Figure 1).

Different habitats had different values for cowbirds. Mesquite thickets were a multi-purpose habitat. They provided the main foraging area for the cowbirds during the early season. The thickets of low mesquite shrubs were also the main areas used for roosting by the cowbirds, and were an important area for nest-searching, as well. Overall, mesquite was second only to the marsh in terms of the number of observations of nest-searching behavior. Marsh habitat, on the other hand, was the main area used for nest-searching, but was only used occasionally for feeding and roosting. Birds were recorded in riparian habitat much more often in the late season (102 records) than in the early season (14 records). Observed activity in riparian areas was primarily nest-searching, with lesser amounts of roosting and feeding.

During the late season (latter part of July and August), cowbirds shifted much of time and activity to non-native habitats, including pastures, and backyards, feeders, and large lawn areas in the towns surrounding Tavasci Marsh. The non-native habitats are apparently important primarily for foraging (Figure 3): there was a moderate amount of roosting behavior noted in suburban habitat, and a small amount of nest-searching behavior, but observed cowbird activity in fields and pastures was limited solely to foraging. Even in the latter half of the season, most nest-searching (62 of 70 observations, 89%) continued to be centered in the marsh and adjacent riparian area, with birds making regular flights back and forth to Tavasci from backyard feeders in Clarkdale and Cottonwood.

Seed feeders in suburban backyards appeared to be one of the main attractions of cowbirds to the suburb areas, attracting numbers of birds. Our radio-tagged cowbirds were frequently noted among flocks of cowbirds at specific feeders in both Cottonwood and Clarkdale. These same feeders were visited repeatedly by some of our color-banded birds (this "habitual" pattern was reminiscent of the movement pattern seen in the marsh, as well, with birds regularly returning to particular spots). Cowbirds in the suburbs would sometimes roost at or in the vicinity of the feeders where they were foraging.

## Conclusions and Recommendations

Our main conclusions from this study are as follows:

1. Relatively large numbers of cowbirds occur in Tavasci Marsh and along the Verde River corridor during the nesting season. The foremost concern related to these cowbird concentrations is their impact on the very small numbers of Southwestern Willow Flycatchers that nest in the Verde Valley (Sferra et al. 1997, Sogge 1995a). Cowbird parasitism may be very heavy on small numbers of Willow Flycatchers (e.g. Sogge 1995b), and cowbird parasitism may have been responsible for nesting failure of the Willow Flycatchers at Tavasci Marsh during the first year of this study. In addition to the Willow Flycatchers, other songbirds nesting in riparian and adjacent desert upland habitats may suffer high levels of cowbird parasitism. We saw evidence of parasitism on Bell's Vireos, Lucy's Warblers, Red-winged Blackbirds, and Blue Grosbeaks in our study area. These and many other nesting passerines are hosts of cowbirds in the Verde Valley and other parts of Arizona (Brown 1994, Johnson 1997)

2. Cowbirds in the Tavasci Marsh area carry out all of their breeding season activities in the same local area, and move only short distances between feeding and nest-searching and roosting. The combination of resources in Tavasci Marsh and the adjacent Verde River riparian corridor provides food, concentrations of other nesting birds to parasitize, and dense thickets for roosting. This apparently allows the cowbirds to stay in one place, and not have to travel long-distance to find resources.

In the first half of the season (May - June), the average of longer-distance movements by cowbirds was less than 1 km. The maximum distance across the range of an individual cowbird that we recorded at this time was 3.8 km. Cowbirds expanded their range in July and August to include agricultural and suburban areas outside of Tavasci Marsh. During this period, the average movement distance increased to 1.8 km, with a maximum di average movement dist individual, radio-marked cowbird of 5.2 km

3. There was a marked behavioral shift among the cowbirds in the area, that was seen in both years. This was the shift of birds from concentrated activity almost entirely within the marsh, with very short movements; to expansion of the birds' range beyond the marsh to make use of pastures, residential lawns, bird feeders and ornamental shrub and tree plantings.

4. With proper placement of traps, the method of capture we used was very effective. We were not attempting to trap exhaustively during this study, and we did not conduct counts specifically to determine the proportion of the local population that we trapped. However, our general observations and surveys during 1997 and 1998 suggest that we did, in fact, capture a substantial portion of the population. During a part of June 1996 when we were holding all cowbirds caught

to try to limit parasitism on local Willow Flycatchers, numbers of cowbirds within the marsh appeared to be noticeably depressed. During general surveys in spring 1998 (after two years of trapping), up to half of cowbirds that we saw around the marsh were banded birds that we had previously captured.

Beezley and Rieger (1987) noted that, in terms of numbers of cowbirds trapped, trapping is more effective in cowbird foraging areas than in riparian (nest-searching) areas. The situation present in Tavasci Marsh (where feeding and nest-searching occur in the same area) allows for a program where effective, intensive trapping can be carried out in the same area where bird species of concern are nesting. This should result in more direct benefits to those species of concern.

Based on the results of this study, we make the following recommendations:

1. A removal trapping program is likely to have significant positive results for nesting success of riparian bird species in this area, including the Endangered Southwestern Willow Flycatcher. Removal trapping has been shown to substantially increase reproductive success of some heavily-parasitized songbirds, including the Southwestern Willow Flycatchers in southern California (Beezley and Rieger 1987, Enos et al 1997). Our project was primarily directed at studying the nature and distance of cowbird movements in the Tavasci Marsh area. It was not intended as a removal program, but nonetheless still succeeded in capturing a substantial portion of the local cowbird population. A program with additional traps, specifically aimed at reducing cowbird numbers, would probably be even more effective.
2. Direct effects of grazing in attracting or supporting cowbirds in the vicinity of nesting Willow Flycatchers are probably quite limited. During the first half of the season (when nest parasitism is most intense), cowbirds were foraging almost entirely in native habitats. Restrictions on grazing are probably more important with respect to the overall quality of habitat where Flycatchers are nesting. In any event, the maximum cowbird movement distances that we recorded were three to five km, depending on the time of season (much shorter than the seven miles used as a guideline for management in the area).
3. A study of feeder use by Brown-headed Cowbirds should be undertaken, to assess the possible contribution of artificial feeding to local cowbird numbers, survivorship, and year-round residence patterns. This might be coupled with an educational effort aimed at reducing backyard feeding during late summer months, or encouraging people to use seed mixes not attractive to cowbirds.

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**Appendix 1.** Banding information for Brown-headed Cowbirds captured as part of study of Cowbird movement in the Tavasci Marsh area, 1996 - 1997. Color band notation is color/color (left leg): color/color (right leg). Sites are: CL - Clarkdale Wastewater Treatment Plant; TM1, TM2, TM3 - Tavasci Marsh, traps 1, 2, and 3 (see text for locations). Colors are: B - blue; G - green; O - orange; R - red; W - white; X - numbered metal band; Y - yellow. Age codes are: A - adult; H - hatch year; SA - subadult.

Date	Site	Band number	Color	Age	Sex
06/07/96	CL	0791-90642	R:Y/X	A	M
06/07/96	CL	1441-90944	Y:Y/X	A	F
06/20/96	CL	0791-90651	G:Y/X	A	M
06/20/96	CL	0791-90652	B:Y/X	A	M
06/24/96	CL	8041-30711	W:Y/X	A	M
06/25/96	TM1	1441-91011		A	F
06/25/96	TM1	1441-91014	Y/W:B/X	A	F
06/25/96	TM1	1441-91015		A	F
06/25/96	TM1	1441-91016	Y/O:B/X	A	F
06/28/96	TM1	1441-91017	R/B:B/X	A	F
06/28/96	TM1	1441-91018	R/G:B/X	A	F
06/28/96	TM1	1441-91019	G/R:B/X	A	F
06/28/96	TM1	8041-30713		A	M
06/28/96	TM1	8041-30714	Y/B:B/X	A	M
06/28/96	TM1	8041-30715		A	M
06/28/96	TM1	8041-30716		A	M
06/28/96	TM1	8041-30717	G/Y:B/X	A	M
07/07/96	TM1			A	M
07/09/96	TM3	1441-91021	W:B/X	A	F
07/09/96	TM3	1441-91022	O:B/X	A	F
07/09/96	TM3	1441-91023	R/R:B/X	A	F
07/09/96	TM3	1441-91024	R/Y:B/X	H	F

Date	Site	Band number	Color	Age	Sex
07/09/96	TM1	8041-30719	R: B/X	A	M
07/09/96	TM1	8041-30720	Y: B/X	A	M
07/09/96	TM1	8041-30721	G: B/X	A	M
07/09/96	TM1	8041-30722	B: B/X	A	M
07/23/96	TM1	0791-90698	O/G: B/X	A	M
07/23/96	TM1	0791-90699	O/Y: B/X	A	M
07/23/96	TM1	0791-90700	O/R: B/X	A	M
07/23/96	TM1	0791-90701	W/O: B/X	A	M
07/23/96	TM1	0791-90702	W/W: B/X	H	U
07/23/96	TM1	0791-90703	G/O: B/X	A	M
07/23/96	TM1	0791-90704	G/W: B/X	A	M
07/23/96	TM1	0791-90705	Y/O: B/X	H	U
07/23/96	TM1	0791-90706	Y/W: B/X	H	U
07/23/96	TM1	0791-90707	Y/Y: B/X	H	U
07/23/96	TM1	1441-91122	O/O: B/X	H	F
07/23/96	TM1	1441-91123	O/W: B/X	H	F
07/23/96	TM1	1441-91124	O/B: B/X	H	F
07/23/96	TM1	1441-91125	W/B: B/X	H	F
07/23/96	TM1	1441-91126	W/G: B/X	H	F
07/23/96	TM1	1441-91127	W/Y: B/X	A	F
07/23/96	TM1	1441-91128	W/R: B/X	A	F
07/23/96	TM1	1441-91129	G/B: B/X	A	F
07/23/96	TM1	1441-91130	G/G: B/X	A	F
07/23/96	TM1	1441-91131	G/Y: B/X	H	F
07/23/96	TM1	1441-91132	G/R: B/X	H	F
07/25/96	CL	0791-90711	O/Y: Y/X	A	M
07/25/96	CL	0791-90712	O/G: Y/X	A	M

Date	Site	Band number	Color	Age	Sex
07/25/96	TM3	0791-90713	B/X:W	A	M
07/25/96	TM3	0791-90714	B/X:O	A	M
07/25/96	TM3	0791-90715	B/X:R/R	A	M
07/25/96	TM3	0791-90716	B/X:R/Y	A	M
07/25/96	TM1	0791-90717	B/X:R/G	A	M
07/25/96	TM1	0791-90718	B/X:R/B	A	M
07/25/96	TM1	0791-90719	B/X:R/W	A	M
07/25/96	TM1	0791-90720	B/X:R/O	A	M
07/25/96	TM1	0791-90721	B/X:B	A	M
07/25/96	TM1	0791-90722	B/X:Y/Y	A	M
07/25/96	TM1	0791-90723	B/X:Y/G	A	M
07/25/96	TM1	0791-90724	B/X:Y/B	A	M
07/25/96	TM1	0791-90725	B/X:Y/W	A	M
07/25/96	TM1	0791-90726	B/X:Y/O	A	M
07/25/96	TM1	0791-90727	B/X:G/R	A	M
07/25/96	TM1	0791-90728	B/X:G/Y	A	M
07/25/96	CL	1441-91141	O/B:Y/X	A	F
07/25/96	CL	1441-91142	O/W:Y/X	A	F
07/25/96	TM3	1441-91143	R/W:B/X	A	F
07/25/96	TM3	1441-91144	R/O:B/X	A	F
07/25/96	TM3	1441-91145	Y/R:B/X	A	F
07/25/96	TM3	1441-91146	Y/Y:B/X	A	F
07/25/96	TM1	1441-91147	B/X:R	A	F
07/25/96	TM1	1441-91148	B/X:Y	A	F
07/25/96	TM1	1441-91149	B/X:G	A	F
07/28/96	TM1	0791-90731	B/B:B/X	H	U
07/28/96	TM1	0791-90732	B/W:B/X	H	U

Date	Site	Band number	Color	Age	Sex
07/28/96	TM1	1441-91152	B/R:B/X	A	F
07/28/96	TM1	1441-91153	B/Y:B/X	A	F
07/28/96	TM1	1441-91154	B/G:B/X	H	F
05/16/97	TM1	1591-17201		A	F
05/16/97	TM1	1591-17202		A	F
05/16/97	TM1	1591-17203		A	F
05/16/97	TM1	1591-17902		A	F
05/16/97	TM1	8101-83903		A	M
05/16/97	TM1	8108-83904		A	M
05/20/97	TM1	1441-17205		A	F
05/20/97	TM1	8101-83905		A	M
05/21/97	TM1	8101-83906		A	M
05/22/97	TM1	1591-17206		A	F
05/26/97	TM1	1591-17207		A	F
05/28/97	TM1	8101-83907		A	M
05/30/97	TM1	8101-83908		A	M
06/04/97	TM1	8101-83910		A	M
06/10/97	TM1	8101-83912		SA	M
06/13/97	TM2	1591-17209		A	F
06/13/97	TM2	1591-17210		A	F
06/13/97	TM2	8101-83913		A	M
06/15/97	TM2	8101-83914		A	M
06/28/97	TM2	1591-17213		A	F
06/28/97	TM2	8101-83916		H	U
06/28/97	TM2	8101-83917		H	U
06/28/97	TM2	8101-83918		H	U
06/28/97	TM2	8101-83919		A	M

Date	Site	Band number	Color	Age	Sex
06/28/97	TM2	8101-83920		H	U
06/28/97	TM2	8101-83921		H	U
06/29/97	TM1	8101-83922		H	U
06/29/97	TM2	8101-83923		H	U
06/30/97	TM1	8101-82924		H	U
07/03/97	TM2	8101-83925		A	M
07/03/97	TM2	8101-83926		H	U
07/03/97	TM2	8101-83927		H	U
07/06/97	TM2	1591-17214		A	F
07/06/97	TM2	1591-17215		H	U
07/06/97	TM2	1591-17216		H	U
07/06/97	TM2	8101-83928		H	U
07/06/97	TM2	8101-83929		H	U
07/08/97	TM1	8101-83930		H	U
07/08/97	TM1	8101-83931		H	U
07/08/97	TM1	8101-83932		A	M
07/08/97	TM1	8101-83933		A	M
07/09/97	TM2	1591-17217		H	U
07/09/97	TM2	1591-17218		H	U
07/09/97	TM2	8101-83934		H	U
07/09/97	TM2	8101-83935		H	U
07/09/97	TM2	8101-83986		SA	M
07/12/97	TM1	1591-17219		H	U
07/12/97	TM2	1591-17220		H	U
07/12/97	TM2	1591-17221		H	U
07/12/97	TM2	1591-17222		H	U
07/12/97	TM1	8101-83937		H	U

Date	Site	Band number	Color	Age	Sex
07/12/97	TM1	8101-83938		H	U
07/12/97	TM1	8101-83939		H	U
07/12/97	TM1	8101-83940		H	U
07/12/97	TM1	8101-83941		H	U
07/12/97	TM2	8101-83942		H	U
07/12/97	TM2	8101-83943		H	U
07/15/97	TM2	8101-82947		A	M
07/15/97	TM2	8101-83944		H	U
07/15/97	TM2	8101-83945		H	U
07/15/97	TM2	8101-83946		H	U
07/15/97	TM2	8101-83948		H	U
07/15/97	TM2	8101-83949		A	M
07/15/97	TM2	8101-83950		H	U
07/15/97	TM1	8101-83951		H	U
07/15/97	TM1	8101-83952		H	U
07/15/97	TM1	8101-83953		A	M
07/15/97	TM1	8101-83954		H	U
07/15/97	TM1	8101-83955		A	M
07/15/97	TM1	8101-83956		A	M
07/15/97	TM1	8101-83957		H	U
07/15/97	TM1	8101-83958		H	U
07/15/97	TM1	8101-83959		A	M
07/15/97	TM2	8101-83999		H	U

**Appendix 2.** Summary data on birds used in a radiotelemetry study Brown-headed Cowbird movements and behavior in the Tavasci Marsh area of central Arizona.

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Transmitter #: 741

Band #: 1441-91144

Band Color Combinations: R:G/S

Date Bird Was Released: 05/19/97

Dates Bird Was Tracked: Begin: 05/19/97 End: 06/07/97

General Location of the Bird's Movements: from 10m near the TM1, to 50m near the TM1, near the trap at Tuzigoot overlook

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Transmitter #: 766

Band #: 1441-91021

Band Color Combinations: B/S:G/B

Date Bird Was Released: 05/21/97

Dates Bird Was Tracked: Begin: 05/21/97 End: 06/13/97

General Location of the Bird's Movements: from road at marsh x-ing and 100 yards P:O, to SE end of TM (1 mile from P:O), to 200 yards from P1 e river, 400m N of TM1 between marsh and mesa, to COYE willow, to N Willard Rd.

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Transmitter #: 767

Band #: 1591-17206

Band Color Combination: B/S:B/O

Date Bird Was Released: 06/05/97

Dates Bird Was Tracked: Begin: 06/05/97 End: 06/23/97

General Location of the Bird's Movements: from old location of TM2, to 300m NE of old TM2, to NW of TM1, to TM1

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Transmitter #: 784

Band #: 1591-17207

Band Color Distribution: B/S:B/O

Date Bird was Released: 06/04/97

Dates Bird was Tracked: Begin: 06/05/97 End: 06/13/97

General Location of Bird's Movements: from COYE Junction, to 10m N of TM1, to 10m SW of TM1 in mesquite, to a yard on Rocking Chair Rd. Near Martia Way

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Transmitter #: 742

Band #:

Band Color Combination:

Date Bird Was Released: 06/16/97

Dates Bird Was Tracked: Begin: 06/18/97 End: 06/23/97

General Location of the Bird's Movements: from mesquite tree at marshy area e. Of TM2, to SE of Sycamore cyn Rd., to west of construction site, to Peck's Lake roadblock NW of marsh, to trap side of marsh (TM2), to COYE Junction

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Transmitter #: 743

Band #:

Band Color Combination: B/X:W/O

Date Bird Was Released: 06/16/97

Dates Bird Was Tracked: Begin: 06/18/97 End: 06/24/97

General Location of the Bird's Movements: from 150m W of TM2, to N across marsh, to E of construction site, to Cottonwood area, to TM2, to Peck's Lake, to Tuzigoot Observatory Platform, to TM2, to base of Tuzigoot by the river

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Transmitter #: 746

Band #: 1441-91019

Band Color Combination: G/R:G/X

Date Bird Released: 06/20/97

Dates Bird Was Tracked: Begin: 06/20/97 End: 06/24/97

General Location of the Bird's Movements: from TM2, to dairy location, to roadblock, to Vicinity NE of Peck's Lake, to Cat-tail edge, to TM2, to Beaver Dam, to COYE Junction, to TM1, to TM2, to TM1

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Transmitter #: 747

Band #: 1441-91015

Band Color Combination: B/X:B/Y

Date Bird Was Released: 06/20/97

Dates Bird Was Tracked: Begin: 06/20/97 End: 06/24/97

General Location of the Bird's Movements: from TM1, to TM2, to old dairy foundation, to roadblock, to marsh overlook, to base of Tuzigoot river

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Transmitter #: 748

Band #:

Band Color Combination: B/X:G/B

Date Bird Was Released: 06/23/97

Dates Bird Was Tracked: Begin: 06/23/97 End: 06/24/97

General Location of the Bird's Movements: from TM1, to mesquite along road 75m west, to 150m SW of TM1, to along river SSE of Tuzigoot

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