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# RECOMMENDATIONS FOR COWBIRD MANAGEMENT IN RECOVERY EFFORTS FOR THE SOUTHWESTERN WILLOW FLYCATCHER

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*Abstract.* The incidence of Brown-headed Cowbird (*Molothrus ater*) parasitism of Southwestern Willow Flycatchers (*Empidonax traillii extimus*) is highly variable, ranging from less than 10% at some sites to over 50% at others. Parasitism usually results in complete loss of flycatcher reproductive output because most parasitized nests are deserted or fledge only a cowbird, although birds that desert often renest. Despite the reduced reproductive output from individual flycatcher nests, it is not clear that cowbird parasitism affects Southwestern Willow Flycatcher population sizes. Cowbird control reduces parasitism rates and increases the reproductive output of Southwestern Willow Flycatchers, but there is no firm evidence yet that it has resulted in any increases of flycatcher populations or forestalled declines, suggesting that populations may be limited by other factors, such as habitat. Cowbird control may nevertheless be an appropriate management option because some populations may benefit and there may be benefits that have not been detected. However, cowbird control efforts should: (a) be applied cautiously and when baseline data indicate serious impacts, because control is expensive and has a number of potentially negative aspects; (b) be geared towards critical assessments of the efficacy of the control, with increases in flycatcher population sizes being the ultimate measure of efficacy; and (c) be regarded as a short term measure, not a permanent management activity.

*Key Words:* brood parasitism, cowbird, cowbird management, cowbird control, *Empidonax traillii extimus,* endangered species, *Molothrus ater,* Southwestern Willow Flycatcher, Willow Flycatcher.

Many factors can lower the reproductive output of passerines (Martin 1992), including predation of eggs and nestlings, poor food resources due to marginal habitat or inclement weather, anthropogenic toxins, and brood parasitism. This paper addresses the ways in which cowbird (*Molothrus* spp.) parasitism affects the endangered Southwestern Willow Flycatcher (*Empidonax traillii extimus*). Key issues considered are whether cowbird parasitism affects host population growth or regulation, whether population level effects on hosts are sufficient to warrant management action, and the most appropriate actions that land managers can take if cowbird management is warranted.

These are complicated issues because cowbirds are native songbirds and because impacts to individual Willow Flycatchers that are parasitized, no matter how severe, may have little or no effect on flycatcher populations. Furthermore, cowbird management consumes large amounts of limited management funds. Approximately a million dollars is spent annually in California alone (Hall and Rothstein 1999), primarily to protect the endangered Least Bell's Vireo (*Vireo bellii pusillus*). On the other hand, even small reductions in Southwestern Willow Flycatcher reproductive success due to cowbirds could make the difference between a declining population and a stable or growing one if a population is experiencing other difficulties.

We limit this paper to consideration of only the Brown-headed Cowbird (*M. ater*). The Bronzed Cowbird (*M. aeneus*) is sympatric with the Southwestern Willow Flycatcher but only two cases of parasitism are known (Skaggs 1996; Arizona Game and Fish Department., unpubl. data). Given its preference for moderate to large passerines (Friedmann and Kiff 1985, Lowther 1995), it is unlikely that the Bronzed Cowbird will ever pose a threat to flycatcher populations.

## IMPACTS OF COWBIRD PARASITISM

Most parasitic bird species specialize on one or a few host species (Johnsgard 1997, Ortega 1998; Rothstein and Robinson 1998a,b; Davies 2000), but Brown-headed Cowbirds are known to have parasitized at least 220 bird species (although at greatly varying intensities) and to have been raised by 144 of these (Lowther 1993). Even individual female cowbirds do not usually specialize on a single host species (Friedmann 1963, Fleischer 1985, Hahn et al. 1999; Alderson and Gibbs 1999a,b). Therefore, parasitism can drive a rare host species to extinction because there is no feedback process that lowers cowbird numbers, and thus parasitism rates, when a rare and heavily impacted host species declines (Rothstein 1975a, Mayfield 1977; Grzybowski and Pease 1999, 2000). Common host species can maintain high cowbird populations even as a rare host is pushed to extinction by parasitism.

Another aspect of cowbird biology that raises the potential of major effects on host populations is the high laying rate of female cowbirds.

Females lay on about 70% of the days during their breeding season (Rothstein et al. 1986, Fleischer et al. 1987), i.e., 42 eggs for a two-month breeding season. However, many and perhaps most of these eggs have little or no effect on host productivity because they are laid in nests lost to predation, in nests of host species that eject them (Rothstein 1977, Robinson et al. 1995a, Hahn et al. 1999), or in the nests of hosts that desert and then renest (Hosoi and Rothstein 2000).

Although nestling cowbirds take no direct action against host young (see Hoffman [1929] in Ahlers and Tisdale [1998a] and Dearborn [1996] for possible rare exceptions), hosts divert parental care from their own offspring to cowbird nestlings and nearly always experience some reduction in their own reproductive output (Pease and Grzybowski 1995, Ortega 1998, Payne 1998). Cowbird nestlings often out-compete host nestlings for food because they usually hatch first (Briskie and Sealy 1990, McMaster and Sealy 1998), and are usually larger (Friedmann 1963, Lowther 1993). Host losses are also due to female cowbirds removing one or more host eggs from nests they parasitize (Sealy 1992) and to host eggs damaged by adult cowbirds (Peer and Sealy 1999). Robinson et al. (1993, 1995a), Ortega (1998), Morrison et al. (1999b) and Smith et al. (2000) provide comprehensive reviews of cowbird biology, impacts, and management.

Cowbird eggs hatch after 11 days of incubation (Lowther 1993) and small hosts with long incubation periods such as the Willow Flycatcher, whose eggs hatch in 12–15 days (Sogge 2000b), experience the greatest losses, usually losing all of their own young if a cowbird egg hatches (Sedgwick and Iko 1999, Whitfield 2000). For Southwestern Willow Flycatchers, only 14% of 133 and 13% of 31 parasitized nests in California in Arizona, respectively, produced any host young, compared to 54% of 190 and 60% of 133 unparasitized nests in these two states (Whitfield and Sogge 1999).

Arcese et al. (1996) have hypothesized that cowbirds depredate unparasitized nests to cause renesting by hosts with nests too advanced to be parasitized, but evidence for this hypothesis is mixed. There are published observations of cowbirds removing nestlings and eggs and therefore acting as predators (Tate 1967, Scott and McKinney 1994, Sheppard 1996, Elliott 1999), but such anecdotal reports do not mean that cowbird nest predation is common. Similar acts of predation have also been documented for other passerines not regularly thought to be predators such as Red-winged Blackbirds (*Agelaius phoeniceus*), Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), Yellow-breasted Chats (*Icteria virens*), and Gray Catbirds (*Dumetella carolinensis*) (Belles-Isles and Picman 1986, Sealy 1994, Cimprich and Moore 1995, Paradzick et al. 2000). Cowbirds were responsible for only one of 25 video-taped predation events of two frequently parasitized host species at a Missouri study site where cowbirds were abundant (Thompson et al. 1999).

If cowbirds preferentially depredate unparasitized nests to cause renesting, unparasitized nests should have higher predation rates than parasitized nests, but no such overall trend has been found (Rothstein 1975b, Kus 1999, Whitfield et al. 1999b). If cowbirds are frequent agents of nest predation, predation should decline when host populations are protected by cowbird removal programs. No such decline is evident for Southwestern Willow Flycatchers, either among years with versus without cowbird removal (Whitfield et al. 1999b), or within the same year between areas with and without cowbird removal (Whitfield 2000). There was also no marked change in predation of Kirtland's Warbler (*Dendroica kirtlandii*) nests after a cowbird removal program began (Walkinshaw 1983). Similarly, Stutchbury (1997) reported that removal of cowbirds had a large effect on parasitism rates of Hooded Warblers (*Wilsonia citrina*), but no effect on reproductive success because nest predation was high in areas with reduced cowbird numbers. The presently available data do not indicate that cowbirds depredate unparasitized nests regularly enough to make this a management concern but additional research is needed. The critical issue is not whether cowbird predation occurs but whether such predation is common enough to significantly impact host populations.

Reductions in reproductive output of individual hosts do not necessarily impact host populations or entire species because density dependent processes, such as habitat availability, may limit passerine birds (Sherry and Holmes 1995). If there is insufficient habitat, decreases in a host's reproductive output due to cowbird parasitism may simply mean that fewer excess individuals die without producing young. Determining whether cowbird parasitism has an impact at the level of a host population or species is the most significant challenge facing conservation biologists concerned with cowbirds and their hosts. Even if parasitism is shown to limit a host species, one must still decide whether that limitation is a cause for concern because every population must ultimately be limited by some factor. Unless population limitation due to parasitism is a recent situation brought about by anthropogenic factors, it is as natural as limitation by competition, habitat, nest predation, or disease.

On the other hand, any factor that limits a rare species or subspecies is a source of concern and may require management action. If parasitism is the reason for a taxon's rarity, then long-term reduction of cowbird impacts may be needed. However, all endangered passerines that appear to be impacted at the population level by parasitism also suffer from a severe scarcity or degradation of habitat due to anthropogenic factors (Rothstein and Cook 2000). It is possible that all of these endangered birds would be able to coexist with cowbirds if their habitat problems were remedied.

## HOST DEFENSES AGAINST COWBIRD PARASITISM

About 25 North American passerine species remove cowbird eggs from their nests nearly 100% of the time. Unlike these ''rejecter species,'' the majority of species, including the Willow Flycatcher, are ''accepters'' and show no egg recognition (Rothstein 1975a, Ortega 1998) and a small number of species have low to moderate levels of egg rejection (Burhans and Freeman 1997). Although accepters do not eject cowbird eggs, they often desert naturally parasitized nests and renest (Friedmann 1963, Rothstein 1975a, Graham 1988). Desertion is primarily or completely a response to detection of adult cowbirds near or at nests (Burhans 2000) and not a response to cowbird eggs, because it is very rare after nests are experimentally parasitized (Rothstein 1975a,b). Parasitized nests are most likely to be deserted by species that have broad habitat overlap with cowbirds and that experience high losses when they accept parasitism (Hosoi and Rothstein 2000), as is the case for Willow Flycatchers.

Southwestern Willow Flycatchers desert about 35–57% of parasitized nests (Table 1). Because small passerines that desert parasitized nests often renest and successfully rear their own young in unparasitized nests (Graham 1988, Hosoi and Rothstein 2000), declines in Willow Flycatcher reproductive output due to cowbird parasitism are much less than the parasitism rate. Increased reproductive effort could theoretically make the costs of renesting significant through adverse effects on adult condition or survival, but such costs have not been detected in Willow Flycatchers (Sedgwick and Iko 1999).

In addition to nest desertion as a host defense, many hosts, including Southwestern Willow Flycatchers (Uyehara and Narins 1995), recognize cowbirds as special threats and attack them or sit tightly on nests to keep cowbirds from laying (reviewed in Sealy et al. 1998). However, such tactics are not very effective, especially for small hosts, which are often parasitized at high rates despite their responses to adult cowbirds because they are unable to drive cowbirds away.

## INDICATORS OF IMPACTS AT THE POPULATION LEVEL

A critical issue in assessing population level impacts is the parasitism rate (% of nests parasitized). Breeding season timing is an important determinant of parasitism rate. In some regions, cowbirds begin to breed later than some of their major hosts and because early nests tend to have the greatest potential productivity, early breeding host species may experience little or no impact at the population level even if late nests suffer high rates of parasitism. However, Southwestern Willow Flycatchers are among the last passerines to breed (Whitfield 2000) and may experience high parasitism levels of their earliest and potentially most productive nests. Willow Flycatchers may also sometimes be subject to unusually high rates of parasitism due to the

TABLE 1. DESERTION RATES OF PARASITIZED WILLOW FLYCATCHERS IN DIFFERENT REGIONS

| Subspecies | Region | New contact?[a] | Parasitism rate (N[b]) | Desertion rate (N[c]) | Reference |
|---|---|---|---|---|---|
| *extimus* | Arizona | No | 7% (203[d]) | 36% (14) | Paradzick et al. 1999 |
| *extimus* | California | Yes | 68% (19) | 57% (14) | Harris 1991 |
| *extimus* | California | Yes | 63% (60) | 45% (38) | Whitfield 1990 |
| *extimus* | New Mexico | No | 22% (129) | 35% (26) | Stoleson & Finch 1999 |
| *trailii* | Colorado | ?[e] | 45% (27) | 82% (11) | Sedgwick & Knopf 1988 |
| *trailii* | Michigan | Yes | 10% (325) | 27% (33) | Berger 1967 |
| *trailii* | Ohio | Yes | 9% (88) | 63% (8) | Holcomb 1972 |

[a] Populations noted as ''yes'' under New Contact were allopatric with respect to cowbirds in pre-Columbian times.
[b] N reflects number of nests for which parasitism status (parasitized or unparasitized) could be determined.
[c] N reflects number of parasitized nests for which desertion status (deserted or not deserted) could be determined.
[d] Most nests were protected by cowbird trapping but within the total sample, parasitism at two sites with no trapping was 0 of 8 nests (Alamo Lake) and 6 of 16 nests (Camp Verde).
[e] Sedgwick and Knopf (1988) thought this high elevation population was only recently exposed to parasitism but it is close to the cowbird's center of abundance in the Great Plains; Chace and Cruz (1998) suggest that cowbirds occurred in the region in the 1800s before bison were nearly extirpated.

TABLE 2. GEOGRAPHIC VARIATION IN COWBIRD PARASITISM RATES (IN THE ABSENCE OF COWBIRD CONTROL) OF SOUTHWESTERN WILLOW FLYCATCHERS FROM DIFFERENT REGIONS (DATA ARE FROM WHITFIELD AND SOGGE (1999) UNLESS NOTED OTHERWISE)

| Locality | Years | Number of nests | Parasitism rate |
|---|---|---|---|
| San Pedro River, AZ | 1995–1996 | 61 | 3% |
| Tonto Creek, AZ | 2001 | 33 | 6%[a] |
| Gila River, NM | 1995, 1997 | 49 | 18% |
| Gila River, NM | 1997–1999 | >129 | 18%[b] |
| Roosevelt Lake, AZ | 1995 | 17 | 18% |
| White Mtns., AZ | 1993–1996 | 36 | 19% |
| Virgin River delta, NV | 1997 | 14 | 21% |
| Santa Ynez River, CA | 1995–1997 | 17 | 29%[c] |
| Verde River, AZ | 1998 | 16 | 38%[d] |
| various sites, NM | 1995 | 10 | 40% |
| Verde River, AZ | 1996 | 13 | 46% |
| Grand Canyon, AZ | 1982–1986, 1992–1996 | 25 | 48% |
| South Fork Kern River, CA | 1987, 1989–1992 | 163 | 66% |

[a] Data from Smith et al. 2002. There was cowbird control at this site in years preceding 2001.
[b] Data from Stoleson and Finch (1999a) and S. Stoleson (pers. comm.). There were 129 nests in 1997–98 and sample size for 1999 nests was not available; hence number of nests is given as >129.
[c] Data from Farmer (1999a). Parasitism rate is an overall one, not a mean of the rate for each separate year covered.
[d] Data from Paradzick et al. (1999).

scarcity of other host species nesting late in the season. Thus cowbird impacts on Willow Flycatcher populations are potentially greater than on most host species. However, late Willow Flycatcher nests are likely to escape parasitism completely because the cowbird laying season generally ends in early to mid-July (Rothstein et al. 1980, Stafford and Valentine 1985, Lowther 1993), although exceptional eggs have been laid into early August (Friedmann et al. 1977:47).

As with all host species (Robinson et al. 1995a), parasitism rates on Willow Flycatchers are highly variable in space and time. Even populations separated by only a few km may experience markedly different parasitism rates (Sedgwick and Iko 1999). In the absence of cowbird control, parasitism of Southwestern Willow Flycatchers ranged from 29% to 66% for California sites, and from 3% to 48% for Arizona sites (Table 2). Because of this large range, baseline studies need to be done on each population to determine whether cowbird parasitism is a serious problem (Whitfield and Sogge 1999). Some populations that incur parasitism may be doing well even without cowbird management efforts. For example, the large Southwestern Willow Flycatcher population in the Cliff-Gila Valley of New Mexico grew despite parasitism rates of 11% in 1997 and 27% in 1998 (Stoleson and Finch 1999a; S. H. Stoleson, pers. comm.).

Given the temporal variability in the frequency of cowbird parasitism (Sedgwick and Iko 1999, Whitfield and Sogge 1999), baseline studies to assess degree of risk due to cowbirds should usually include at least two and preferably more years of data collection before cowbird management is considered. However, a first year of data collection showing a rate of parasitism of >30% may alone warrant cowbird control management (U.S. Fish and Wildlife Service 2001). Impacts of parasitism can be reduced during baseline studies by removing cowbird eggs from accessible parasitized nests (if authorized by the U.S. Fish and Wildlife Service) or by addling them, as a cowbird egg in a nest may reduce the chances of subsequent parasitism (Ortega et al. 1994). Such manipulations have proven effective with another endangered cowbird host (Kus 1999).

## RECENT ECOLOGICAL CHANGES THAT MAY HAVE INCREASED COWBIRD IMPACTS

Cowbird fossils from California, Florida, Virginia, New Mexico, and Texas date from 10,000 to 500,000 years ago (Lowther 1993), and DNA sequence data indicate that cowbirds have been in North America for at least 800,000 years (Rothstein et al. 2002). Thus cowbirds are an ancient component of the North American fauna, so impacts on endangered host species are likely to be due to major ecological changes such as a loss or deterioration of breeding habitat, something well recognized as the major cause of the decline of the Southwestern Willow Flycatcher (Unitt 1987; U.S. Fish and Wildlife Service 1995, 2001) and other endangered species impacted by cowbirds (Rothstein and Cook 2000). Another possible ecological change that could perturb stable cowbird-host interactions is an increase in the abundance and distribution of cowbirds. Host populations that have only begun to experience parasitism due to recent cowbird range extensions might be especially likely to decline if they are deficient in evolved host defenses. Given these considerations, trends in cowbird numbers and range extensions are important issues.

The first available historical records show the presence of cowbirds in the mid-1800s throughout the Southwest as far west as the Colorado River (Rothstein 1994). Cowbirds colonized southern California and all of the area west of the Sierra Nevada and Cascades since 1900. Thus parasitism is a new pressure only for Southwestern Willow Flycatchers in California. However, cowbirds might be more common and more widespread today than under original conditions, even within their historical range. Some early pre-1920s visitors to the cowbird's original range in the Southwest reported that cowbirds were uncommon, while others reported them to be common in habitats used by Southwestern Willow Flycatchers (Whitfield and Sogge 1999, Periman and Kelly 2000). Parasitism rates of Southwestern Willow Flycatchers showed large increases after the early 1900s when data for California and Arizona were lumped (Whitfield and Sogge 1999). However, it is unclear if the same temporal trend would occur if analysis were restricted to only data for the original contact areas in Arizona.

Although there is uncertainty concerning cowbird population trends over the last century, Breeding Bird Survey (BBS) data provide reliable indicators of recent population trends. Averaged across North America, cowbirds have shown a statistically significant ($P < 0.01$) decline of 1.0% per year since the inception of the Survey in 1966 (Sauer et al. 2000). Focusing on the states that contain the largest numbers of Southwestern Willow Flycatchers, cowbirds declined moderately in Arizona and California and increased moderately in New Mexico (all trends statistically nonsignificant) from 1966 to 1999. Even if cowbirds have not increased since the 1800s, Willow Flycatchers and other riparian species have decreased due to habitat loss. Thus increasing cowbird-to-host ratios may have resulted in escalated rates of parasitism even in areas of historical sympatry between cowbirds and Southwestern Willow Flycatchers. Increased cowbird impacts in the absence of increased cowbird numbers may be especially likely in riparian habitats because cowbirds show a distinct preference for riparian habitats in the West (Farmer 1999b, Tewksbury et al. 1999).

## CAN SOUTHWESTERN WILLOW FLYCATCHERS AND COWBIRDS COEXIST?

It is clear that most Southwestern Willow Flycatcher populations are viable even when exposed to cowbird parasitism, at least under primeval conditions, because cowbirds have long occurred over most of the flycatcher's range. Southwestern Willow Flycatchers in southern California only recently exposed to cowbird parasitism might not be viable in the presence of cowbirds, because they lack evolved defenses against cowbirds, as proposed for the Least Bell's Vireo (U.S. Fish and Wildlife Service 1998). However, desertion and renesting after parasitism is as frequent in southern California flycatchers as in populations further east with longer histories of parasitism (Table 1). The occurrence of high nest desertion tendencies in California Willow Flycatchers is likely due to retention of host defenses that evolved in ancestral populations that experienced cowbird parasitism (Hosoi and Rothstein 2000) and/or gene flow from parasitized populations. Thus available evidence indicates that newly exposed populations can coexist with cowbirds, unless they are experiencing a marginal existence due to other stresses such as loss of habitat, high levels of nest predation, or low levels of juvenile and adult survival.

A demographic analysis of the Southwestern Willow Flycatcher population along the Kern River indicated that under current conditions, this population cannot grow unless parasitism is about 10% or less (Uyehara et al. 2000). A population that cannot sustain itself in the presence of such a low parasitism rate is probably endangered by factors other than cowbird parasitism. This same population was able to remain stable and possibly even grow from 1982–1989 (Whitfield 1990, 2000) despite a 68% parasitism rate in 1987 (Harris 1991), the only year this rate was determined. Thus it is likely that some critical variable has changed in recent years. In short, available data indicate that Southwestern Willow Flycatchers in all regions can co-exist with cowbirds unless they also experience some new pressure such as severe habitat losses.

## DOES COWBIRD PARASITISM NECESSITATE MANAGEMENT ACTIONS?

As described above, cowbird parasitism per se does not necessarily warrant management action. Parasitism is a naturally occurring process and may have little or no effect on the size of host breeding populations, even if it causes major reductions in host breeding success. Cowbirds are native birds and as such are important to biodiversity. They may even affect overall avifaunas in complex and unexpected ways, by, for example, limiting the numbers of some common species and thereby allowing the persistence of other species that might otherwise be out-competed, as is the case for some predators that enhance biodiversity (Simberloff 1998).

Nevertheless, there are some circumstances in which it may be prudent to employ management actions to deter cowbird parasitism. The circumstances that should trigger cowbird management may differ from site to site because of site-specific factors such as a host population's current size, recent population trend, parasitism rate, amount of suitable habitat, and the extent of the losses attributable to cowbird parasitism. These and other factors are discussed in greater detail below, but management actions are constrained by what is possible to achieve. For example, no amount of cowbird management will result in growth of a flycatcher population that is limited by habitat. Furthermore, if such a population is small, it would contribute negligible numbers of individuals that might disperse to other populations. So first we review the range of management actions that may be available.

## POTENTIAL APPROACHES TO COWBIRD MANAGEMENT

Cowbird distribution and abundance may be reduced by landscape-wide measures that limit anthropogenic influences that benefit this species. Cowbirds typically feed in areas with short grass (Friedmann 1929, Morris and Thompson 1998) and in the presence of ungulates such as bison and domesticated livestock. Cowbirds also often feed at campgrounds, suburban areas with lawns and bird feeders, and golf courses. It is unclear whether cowbirds always require anthropogenic food sources or native ungulates (Goguen and Mathews 1999) but reductions in the former might reduce cowbird numbers over large regions.

Attempts to limit cowbird numbers on landscape scales should consider the cowbird's commuting behavior (Rothstein et al. 1984, Thompson 1994, Ahlers and Tisdale 1999a, Curson et al. 2000, Sechrist and Ahlers *this volume,* Tisdale-Hein and Knight *this volume*). In many regions, cowbirds spend the morning dispersed over host-rich areas such as forest edges or riparian strips. They typically leave these breeding ranges by late morning to early afternoon and commute to feeding sites, where groups may feed on concentrated food sources. If cowbirds are to be reduced by removing anthropogenic food sources, these removals need to be done over spatial scales that exceed the distances over which most local cowbirds commute. Although maximum commuting distances of 7 km (Rothstein et al. 1984) and 14 km or more (Curson et al. 2000) have been reported, most individuals commute shorter distances, as cowbird abundance declines over distances as short as 2–4 km from anthropogenic food sources (Verner and Rothstein 1988, Tewksbury et al. 1999, Curson et al. 2000, Sechrist and Ahlers *this volume*). Given the pervasiveness of human influence, and the lack of commuting behavior in areas with widespread feeding opportunities for cowbirds, there may be few instances in which landscape-level management measures can completely eliminate local cowbird populations. However, cowbird abundance may at least be reduced by landscape-level actions, although this may not provide sufficient protection if a flycatcher population is severely impacted by cowbirds. Furthermore, landscape-level measures may be costly and time consuming if activities and facilities such as grazing and golf courses are curtailed. In addition, land managers should stress reductions in anthropogenic food sources only if the sources subject to their regulatory action are the major food sources in an area. For example, if there are feeding sites for cowbirds that will remain after regulatory actions, there may be little justification for limiting cattle grazing, although the direct impacts of cattle will often warrant their removal from riparian habitats (Belsky et al. 1999a).

Parasitism rates and cowbird densities may decline with increases in vegetation density (Larison et al. 1998, Averill-Murray et al. 1999; Farmer 1999a,b; Spautz 1999, Staab and Morrison 1999; but see Barber and Martin 1997), because nests may be more difficult to find in dense vegetation. Thus cowbird parasitism might be reduced by measures that result in denser riparian vegetation. Furthermore, managers should also vigorously pursue long term efforts to augment habitat because habitat loss or degradation is probably the ultimate cause of decline for all endangered hosts (Rothstein and Cook 2000), including the flycatcher (U.S. Fish and Wildlife 2001). However, attempts to increase and improve habitat, for example by increased water flows, are fraught with economic and political constraints that can delay changes for years. Unfortunately, flycatcher populations threatened by parasitism may require actions that produce benefits more quickly. Therefore, although land managers should have long range goals that augment the quality and extent of habitat and that address landscape-level actions in regions where parasitism is a threat, cowbird control will often be the most effective action if cowbird impacts justify management intervention.

Cowbirds are highly social (Rothstein et al. 1986) and are attracted to decoy traps, which can remove most individuals from large areas (Eckrich et al. 1999, DeCapita 2000, Griffith and Griffith 2000). Shooting cowbirds attracted to playback of female calls (Rothstein et al. 2000) can be a valuable supplemental way to reduce cowbird numbers (Eckrich et al. 1999). Removing or addling cowbird eggs from parasitized nests can further reduce host losses (Ortega et al. 1994, Hall and Rothstein 1999). Although trapping is usually the most effective means of cowbird control, shooting cowbirds and removing/addling cowbird eggs may be more cost effective and practical if cowbird and/or local host numbers are low and where the set-up and servicing of traps is difficult (Winter and McKelvey 1999).

## EFFECTIVENESS OF COWBIRD CONTROL

Cowbird trapping efforts are typically highly successful in reducing parasitism rates and increasing host reproductive output. Cowbird trapping along the South Fork of the Kern River increased the mean number of young each female Southwestern Willow Flycatcher fledged per season from 1.04 before control to 1.88 afterwards (Whitfield et al. 1999a). Cowbird control has resulted in similar productivity increases with three other endangered species: Black-capped Vireo (*Vireo atricapillus*; Eckrich et al. 1999, Hayden et al. 2000), Least Bell's Vireo (Griffith and Griffith 2000), and Kirtland's Warbler (DeCapita 2000). However, the efficacy of cowbird control efforts for Southwestern Willow Flycatchers can not be assessed in some cases in California and Arizona because baseline data on parasitism rates and host nesting success were not collected before control began (Winter and McKelvey 1999).

Despite its effects on the productivity of host nests, cowbird control has a mixed record when it comes to increases in host breeding populations (Rothstein and Cook 2000). The Least Bell's Vireo and Black-capped Vireo have generally increased markedly since cowbird control began (Eckrich et al. 1999, Griffith and Griffith 2000), although little attempt has been made to assess the extent to which other management actions, such as improved and expanded habitat, have contributed to the increases. On the other hand, Kirtland's Warbler and Southwestern Willow Flycatchers at the Kern River did not increase after cowbird trapping; trapping may have forestalled further declines in these species (DeCapita 2000; Whitfield et al. 1999a, 2000) but Rothstein and Cook (2000) argue that the evidence for such effects is far from conclusive.

Focusing on the Willow Flycatcher, the Kern River Valley population has declined from 34 pairs in 1993 to 12 pairs in 2000 despite cowbird trapping since 1993. Cowbirds have been controlled at Camp Pendleton since 1983 to aid recovery of the Least Bell's Vireo (Griffith and Griffith 2000). Despite a report of a modest increase in Willow Flycatchers as of 1991 (Griffith and Griffith 1994), there has been no marked increase in flycatchers as of 2000 after 18 years of cowbird control, even though there appears to be suitable habitat that remains unoccupied. Because it is designed to protect Least Bell's Vireos, cowbird trapping at Pendleton ends well before the Willow Flycatcher breeding season ends. However, only minimal numbers of cowbirds remain when Willow Flycatcher breeding begins in June (Griffith and Griffith 2000) and no parasitism of flycatchers has been detected since nest monitoring began in 1999 (B. Kus, pers. obs.). As with Camp Pendleton, long term cowbird trapping to protect Least Bell's Vireos at another southern California site, the Prado Basin, has not resulted in an increase in the small number of flycatchers (three to seven territories per year) that breed there (Pike et al. 1997).

Trapping programs to protect flycatchers began in 1996 and 1997 in Arizona (Table 3). No baseline data on parasitism rates were collected and local flycatcher habitat was not completely surveyed at some sites before trapping began. A critical assessment of the efficacy of cowbird control for these Arizona populations can only be done after compensating for changes in survey effort and in habitat area and quality; unfortunately, available data do not allow such compensations. The best overall assessment by field workers familiar with these populations is that increases at the Roosevelt Lake, Salt River inflow site reflect the effects of increased survey effort and increased habitat but may also be partially attributable to cowbird control. It is worth noting that there may have been population increases at other sites (e.g., Gila sites) before control began and that the Greer/Alpine site declined after control began, although it may have already been at dangerously low levels (Table 3).

Data from San Marcial, along the Rio Grande in New Mexico, show no clear benefits of cowbird trapping. This site had six flycatcher nests in 1995 when there was no cowbird control. Control occurred in 1996, 1997, and 1998 when there were one, two, and two nests, respectively (Robertson 1997; Ahlers and Tisdale 1998b, 1999b). At present no conclusive results arise from these Arizona and New Mexico data but it seems clear that there has not been a rapid increase in any flycatcher population soon after cowbird control began, unlike the increases in

TABLE 3. NUMBERS OF SOUTHWESTERN WILLOW FLYCATCHER PAIRS COUNTED AT ARIZONA SITES BEFORE AND AFTER COWBIRD CONTROL BEGAN

| Site/Area | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|
| Alamo Lake | 0 | 0 | 2 | 4 | 6 | 9 | **21**[a] | **20** | **15** |
| Alpine/Greer | 7 | 10 | 10 | 13 | **7** | **7** | **5** | **3** | **2** |
| Gila River sites | 0 | 0 | 0 | 3 | **30** | **46** | **58** | **48** | **40**[b] |
| Roosevelt Lake, Salt River inflow | 1 | 15 | 9 | **18** | **17**[a] | **20** | **52**[c] | **80** | **106** |
| Roosevelt Lake, Tonto Creek inflow | 1 | 7 | 8 | **11**[a] | **18** | **23** | **22** | **25** | **25** |
| San Pedro River | 3 | 30 | 26 | 27 | **40**[a] | **38** | **61**[c] | **59** | **67** |

*Notes:* Data underlined and in bold denote years with cowbird control. Inferences concerning numerical trends after cowbird control began are complicated by changes in habitat extent and quality, survey intensity and amount of area surveyed (see text). Data are from Arizona Game and Fish Department, and White and Best (1999).

[a] Higher numbers of birds are likely due to increased survey effort not to an actual increase in the population.

[b] Cowbird control has occurred at only one of several sites.

[c] Higher numbers of birds in these and subsequent years are likely to reflect actual increases in populations due to increases in amount and/or quality of habitat.

Least Bell's Vireos immediately after cowbird control (see Griffith and Griffith 2000).

Even if it results in the growth of a host's breeding population, cowbird control is a stopgap measure (U.S. Fish and Wildlife Service 1995) that must be done for a number of years if a host population is to continue growing. This continued effort is needed because all cowbird control programs show that control either has no effect on cowbird numbers in subsequent years (Eckrich et al. 1999, DeCapita 2000, Ahlers and Tisdale 1999b, Griffith and Griffith 2000) or too small an effect to reduce parasitism to negligible levels (Whitfield et al. 1999a). Although intensive cowbird trapping efforts do not negate the need for trapping in subsequent years, it is possible that trapping may not be needed as a permanent solution. If a small host population grows and becomes large as a result of cowbird trapping and possibly other measures, it may experience reduced parasitism rates as increased host numbers lower the per capita risk of parasitism. These lower rates of parasitism might have no significant impacts on host population dynamics. Stopping cowbird control after a local host population has increased greatly would reveal whether parasitism rates are lower than when the population was much smaller. It could also have high management value because considerable resources would be saved if parasitism rates were so low that yearly cowbird control is no longer necessary. For these reasons, it is premature to conclude that an endangered host will require cowbird control in ''perpetuity'' as is done in the draft recovery plan for the Least Bell's Vireo (U.S. Fish and Wildlife Service 1998). Nevertheless, if cowbird parasitism is indeed a limiting factor given the amount of currently available habitat, agencies may have to commit to a decade or more of cowbird trapping. But the most critical question facing mangers is whether cowbird management is likely to produce significant benefits and whether the funds used for such management might produce greater benefits if expended on other measures, such as habitat augmentation.

## REASONS FOR CAREFUL DELIBERATION IN THE INITIATION OF COWBIRD CONTROL PROGRAMS

Managers need to be flexible in their approaches and should not assume that cowbird control is one of the very first things that should be done when parasitism of a population of any endangered species is documented. Similarly, managers should not adopt cowbird control just because funding becomes available, and regulators should not earmark management funds to cowbird control simply because this is an easily executed action. An endangered host may benefit more in the long run by first using funds to monitor the extent and impacts of parasitism, as data may show that funding will be of more benefit if applied to management actions unrelated to cowbirds.

We suggest some caution in initiating cowbird control programs for two reasons. First, while cowbird control typically increases reproductive output, evidence to date indicates that it does not usually result in increases in flycatcher breeding populations. The extra birds that are produced may not be recruited into the breeding population because flycatchers may be limited by breeding, wintering, or migration habitat (see papers in Finch and Stoleson [2000]). Nevertheless, cowbird control may yet prove to boost some flycatcher populations to which it is applied. Moreover, it is possible that the extra flycatchers produced by flycatcher populations protected by cowbird control may disperse to other populations. Indeed, determining whether such dispersal occurs and benefits overall metapopulations is a major research need.

Our second reason for urging caution arises from a series of potential problems associated with cowbird control. A cowbird control program with little prospect of producing significant benefits uses funds that could likely produce greater benefits for flycatchers if spent in another manner. Besides using limited resources in a less than optimal way, ineffective control programs may deter attention from other management needs. In a worst case scenario, cowbird control might be used to legitimize harmful activities. For example, cowbird control may be done to mitigate livestock grazing on public lands, when in fact the real harm is habitat damage due to overgrazing rather than cowbird attraction. Benefits of cowbird control might be insignificant because pre-control levels of parasitism were low, because a remote habitat patch has too little habitat to support more flycatchers, or for other reasons. A cowbird control program that has little prospect of producing important benefits is especially unfortunate because it may waste resources for many years, as control programs tend to continue indefinitely.

Control programs typically continue indefinitely because control in one year usually has little effect on cowbird numbers in subsequent years. In fact, cowbird control programs often take on a life of their own, perhaps because they can be highlighted as proactive management, with the numbers of cowbirds killed becoming a numerical indicator of a positive benefit. For example, intense cowbird control continues for Least Bell's Vireo management at Camp Pendleton after almost 20 years despite a 20 fold increase in vireos (Griffith and Griffith 2000) and for Kirtland's Warbler management in Michigan after over 30 years despite a five fold increase in warblers (DeCapita 2000). In both cases, managers show little interest in reducing cowbird trapping efforts to determine whether intensive control is still needed (S. Rothstein, pers. obs.). Management actions that would produce long-term benefits and reduce or eliminate the need for yearly actions are clearly preferable but may not be enacted because of conflict with special interest groups. An example is grazing and the cowbird control program to protect the Black-headed Vireo at Fort Hood, Texas. Experimental reduction of cattle numbers on large parts of this army base has been shown to reduce cowbird numbers (Cook et al. 1998, Koloszar and Horne 2000) leading Cook et al. (1998) to conclude that ''The need for [cowbird] trapping is largely a result of a continuous and loosely regulated grazing system on the installation.'' Nevertheless, managers have opted to continue extensive cowbird trapping and intense grazing even though cowbird attraction is not the only impact grazing has on the base's natural resources (Sanchez and Batchelor 2000). Finally, an important issue associated with cowbird control is whether a species can legally or logically be removed from the endangered species list as long as human intervention (i.e., cowbird control) continues.

Because the ultimate value of cowbird control is not known, control should never be the sole mitigation measure to compensate for habitat destruction of any endangered species. This is especially true if cowbird control is initiated with insufficient baseline data on the extent of parasitism. In the absence of baseline data, huge sums of scarce management funds may be spent for no good purpose and cowbird control is indeed expensive, with contractors generally charging around $2000 per season for each trap. If cowbird control is adopted as a mitigation for habitat loss, there would in fact be no mitigation if parasitism had little effect on the population impacted by habitat loss.

Cowbird trapping is often done by private consulting firms, which raises the issues of profit incentives and consultant advocacy becoming the impetus for such programs. While there is nothing inherently wrong with profiting from such work, managers and regulators should base cowbird control decisions on the work of researchers who do not profit from control. Another reason for initiating control programs only when well justified is the need to show that native animals are being killed only when there is a good reason to do so. Killing large numbers of a native songbird, such as the cowbird, when there is no basis for expecting significant benefits is ethically questionable and could create a public opinion backlash that jeopardizes control programs that are worthwhile. Likewise, capturing non-target species is of concern. Griffith and Griffith (1994), for example, reported 8453 captures of about 1500 individuals of non-target species during a single year of cowbird trapping at Camp Pendleton. Species other than cowbirds have higher mortality rates in traps and may suffer breeding failure due to time spent away from their nests.

## RECOMMENDATIONS FOR THE INITIATION AND DESIGN OF COWBIRD CONTROL PROGRAMS

Cowbird control to aid local Willow Flycatcher populations should be instituted after baseline data show parasitism rates to be above a critical level (U.S. Fish and Wildlife Service 2001), as also proposed in recovery plans for other endangered southwestern hosts such as the Golden-cheeked Warbler (*Dendroica chrysoparia*) and Black-capped Vireo (U.S. Fish and Wildlife Service 1991, 1992). In a review of cowbird management for hosts in general, Smith (1999) recommended that management should only be considered if parasitism is >60% for two or more years, but listed a number of considerations that dictate raising or lowering this threshold. In particular, he recommended that the critical parasitism level for management considerations be lowered to >50% for species listed as threatened or endangered.

Given the Southwestern Willow Flycatcher's low numbers (Sogge et al. *this volume*), we recommend that cowbird control should be considered if parasitism exceeds 20–30% after collection of two or more years of baseline data (see also U.S. Fish and Wildlife Service 2001). But this guideline should be applied with flexibility that gives weight to available data on local populations, such as current population trends. For example, there has been a decline in flycatchers at the South Fork Kern River since cowbird control began, despite a reduction in parasitism rates from 65% to 11–20% from 1994–1999 (Whitfield et al. 1999b; M. Whitfield, unpubl. data); intensified control that reduces parasitism even further might be suitable for this population. However, the large Cliff-Gila site in New Mexico grew between 1997–99 despite parasitism rates of 11–27%; rates of 30% or even higher may not warrant cowbird control for this population.

Monitoring nests to collect baseline data on parasitism rates can be costly, but could save funds in the long run if it shows that control is not necessary. Although available resources may make it unrealistic to monitor nests in all small populations, populations with more than five territories should be monitored. If available funds allow attention only to some small populations, managers should give higher priority for both control and nest monitoring to populations that do not appear to be limited by habitat availability. Cowbird eggs should be removed or addled during years when nests are monitored, unless a population is part of an experiment designed to test whether cowbird trapping alters flycatcher population trends (next paragraph).

If a cowbird control program is initiated, we recommend development of an initial statement of goals that define conditions that will end the control program and periodic (3–5 year) peer reviews that judge the program's efficacy. Because current cowbird control programs have not yet resulted in clear increases in Southwestern Willow Flycatchers, we also recommend that overall control programs should be designed as experiments that have the potential for critical assessments of the efficacy of control. To accomplish this, populations with cowbird control should be compared with a limited number of comparable populations that have no cowbird control. We also advise that managers should re-evaluate the need for continued cowbird control if a flycatcher population has grown to be large, because enlarged host populations may experience lowered levels of parasitism, even in the absence of cowbird control.

In addition, we remind managers that the goal of cowbird control is to aid impacted host populations, not to maximize the number of cowbirds killed. Although the number of cowbirds killed can be increased by trapping at cowbird feeding sites and at times other than a host's breeding season, managers need to determine whether these trapping policies provide increased protection for endangered hosts. There is little justification for trapping outside of an endangered host's breeding season if this trapping results in killing large numbers of migratory cowbirds. Trapping from 1 May to 31 July should provide maximal protection for Southwestern Willow Flycatchers. Trapping in host breeding habitat is likely to be the best strategy in most situations as this removes the cowbirds that may put hosts at risk. However, conditions in some local landscapes may make trapping at cowbird feeding sites worthwhile. Because no single control protocol is best for all situations, managers should consult a range of published, peer-reviewed accounts of cowbird control programs (e.g., Eckrich et al. 1999; Whitfield et al. 1999b, 2000; Winter and McKelvey 1999, DeCapita 2000, Griffith and Griffith 2000) for information on the design, number, placement, and visit schedule for traps, on humane euthanasia methods, and on activities that may supplement trapping.

Managers also need to ensure that impacts on non-target species are minimized, e.g., by adjusting the sizes of trap openings to reduce captures of other species, and by visiting traps once or more per day to release all non-target birds as quickly as possible. However, reasonable levels of unavoidable negative impacts on common, non-target species should not deter cowbird trapping if control is well justified. Impacts on non-target species are an undesirable but unavoidable consequence of trapping programs that benefit endangered hosts.

Lastly, managers should initiate public education programs to inform the public about the justification for controlling cowbirds and about other measures that can reduce cowbird numbers such as suspending bird feeding activities during the passerine breeding season. If cowbird control elicits complaints that it is wrong to kill one native bird to help another, managers should explain that control is viewed as a short-term management tool necessitated by increased rates of parasitism and/or drastically reduced host populations that are threatened by loss of reproductive potential. Managers should explain that action against one native bird to aid another reflects no value judgment as to the worth of one species over another but instead reflects society's commitment to conserve endangered species and maintain levels of biodiversity.

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