Appendix F.

COWBIRD PARASITISM AND THE SOUTHWESTERN WILLOW FLYCATCHER: IMPACTS AND RECOMMENDATIONS FOR MANAGEMENT

1. Introduction

High rates of successful reproduction are essential for the survival and growth of populations of the southwestern willow flycatcher (*Empidonax traillii extimus*), as is the case for all small to moderate sized passerines. Large numbers of young must be produced to make up for the high mortality rates that are normal for adult passerines in temperate regions, about 44.7-64.5% for female willow flycatchers (Sedgwick and Iko 1999, Whitfield et al. 1999). Because of this high annual mortality, most willow flycatchers do not live long enough to breed in more than one breeding season. Many factors act to lower the reproductive output of passerines (Martin 1992), including predation of eggs and nestlings, poor feeding conditions due to marginal habitat or inclement weather, anthropogenic toxins and cowbird parasitism. This paper addresses the ways in which cowbird parasitism affects willow flycatcher reproduction, whether such effects are important to population growth or regulation on local and regional bases, whether population level effects 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, widespread songbirds that are closely associated with human activity and because impacts to individual willow flycatchers that are parasitized, no matter how severe, may have little or no effect on flycatcher populations. On the other hand, even small reductions in willow flycatcher reproductive success could be the difference between a declining population versus a stable or slowly growing one if a population is experiencing other difficulties. This paper's goal is to provide the necessary background information needed for managers to make appropriate decisions regarding cowbirds; a basic message throughout the document is that managers need to be flexible rather than reflexive when it comes to cowbird parasitism. Predation of eggs and nestlings lower flycatcher reproductive output as much as or more than cowbird parasitism. However, management actions at present need to focus on parasitism, when it is sufficiently intense according to the guidelines laid out herein, because there are no feasible means of lowering nest predation without severely impacting entire ecosystems, unlike the case for deterrence of cowbird parasitism. Predation and the need for research on acceptable means to deter it are discussed in an appendix to this paper.

To guide the reader through this document an outline of the remaining major sections appears below. Readers familiar with cowbird and host biology can skip to section 7; those wanting a quick guide to management recommendations can skip to section 11.

2. Background on brood parasitism.
3. Cowbird impacts on host populations.

4. Host defenses against cowbird parasitism.
5. Key indicators of impacts at the population level.
6. Recent changes that may be responsible for possible increases in cowbird impacts.
7. Can southwestern willow flycatcher populations survive in the presence of cowbird parasitism?
8. Does cowbird parasitism necessitate management actions? .
9. Potential management approaches.
10. Is cowbird control a longtime or even permanent need?
11. Conclusions regarding cowbird management methods.
12. Potential positive and negative aspects of cowbird control.
13. Recommendations for cowbird management.

Appendix. The importance of nest predation and potential management actions.

2. Background on Brood Parasitism

Brood parasitism is an alternate form of breeding biology in which animals lay eggs in the nests of other individuals, their hosts, which then provide all needed parental care. This form of breeding biology has been widely studied in birds and insects (Davies et al. 1989). Among birds, parasitism can be intraspecific or interspecific. In intraspecific parasitism, which occurs in numerous bird species, individuals lay eggs in nests tended by other members of their own species. Interspecific parasitism involves laying eggs in the nests of other species. Worldwide, about 1% or roughly 100 species of birds are obligate interspecific parasites, meaning that no members of their species care for their own young (Rothstein and Robinson 1998). One or more species of obligate interspecific parasites occur over most of the land masses of all continents except Antarctica and this form of breeding biology has evolved independently six to eight times among extant bird species. Recent books providing general treatments of avian brood parasitism are Johnsgard (1997), Ortega (1998) and Rothstein and Robinson (1998).

Three obligately parasitic birds occur in North America, the brown-headed, bronzed and shiny cowbirds (*Molothrus ater, M. aeneus* and *M. bonariensis*, respectively). Lowther (1993, 1995) provides reviews of the overall biology of the first two species and Ahlers and Tisdale (1998a) have compiled a useful annotated bibliography for the genus *Molothrus*. Only the brown-headed cowbird is widespread in the United States, with breeding occurring in all states except Hawaii and only it has been implicated frequently in declines of other bird species in North America. The bronzed cowbird occurs sporadically from southeastern California to southern Louisiana and may be a factor, along with habitat loss, in declines of several oriole species (*Icterus* spp.) in the Lower Rio Grande Valley (Brush 1993, Brush pers. comm.). Bronzed cowbirds generally parasitize moderate to large passerines (Friedmann and Kiff 1985) and there are no published reports of parasitism on willow flycatchers in the scientific literature.

There was only one case of bronzed cowbird parasitism among the hundreds of southwestern willow flycatcher nests monitored in the 1990s in Arizona and New Mexico, a New Mexico nest cited Skaggs (1996). Therefore, this cowbird is not a management concern at present given the rarity with which it parasitizes willow flycatchers. The shiny cowbird has recently begun to occur in southern Florida and may be breeding there (Cruz et al. 1998). Because of the restricted ranges of the bronzed and shiny cowbirds, this paper focuses only on brown-headed cowbirds. However, if the two former cowbird species were to increase substantially in distribution and abundance, they too might require attention as regards management issues (Cruz et al. 1998). All further mention of cowbirds refers to the brown-headed cowbird.

Most parasitic bird species specialize on one or a few host species, or a complex of similar species, but brown-headed cowbirds are generalists and parasitize most co-occurring passerine species, although at greatly varying intensities. They are known to have parasitized at least 220 bird species and to have been raised by 144 of these (Lowther 1993). Even individual female cowbirds do not specialize on a single host species (Friedmann 1963, Fleischer 1985, Hahn et al. 1999). 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). In other words, common host species could maintain high cowbird populations even as a rare host is pushed to extinction by cowbird parasitism. Another aspect of cowbird biology that raises the potential of major effects on host populations is the large number of eggs individual females lay. Studies from diverse regions and habitats across North America used postovulatory follicles or oviducal eggs to assess cowbird laying rates and reported that females lay eggs on about 70% of the days during their breeding season (Rothstein et al. 1986, Fleischer et al. 1987). This laying rate translates to 42 eggs for a two month breeding season and 40 or more eggs per season is commonly cited as the likely number of eggs females lay. However, many, perhaps most, of these eggs have no effect on host productivity because they are laid in nests that are lost to predation or in nests of host species that eject them (Rothstein 1977, Robinson et al. 1995a). Furthermore, a recent study (Hahn et al. 1999) that used molecular markers to determine the identity of laying females responsible for cowbird eggs and nestlings found in host nests estimated that a female's "effective fecundity" is only 2 to 8 eggs. Effective fecundity refers to cowbird eggs that are laid in nests of hosts that accept cowbird eggs. These new data suggest that cowbirds have much less potential to impact host populations than is currently believed to be the case (Hahn et al. 1999). More research is needed on this important issue because it is possible that Hahn et al. (1999) did not find all of the nests in which cowbirds might have laid eggs, whereas previous studies using the postovulatory follicle or oviducal egg methodologies are reliable in revealing numbers of eggs laid.

Unlike some brood parasites, whose young directly kill off all host young, nestling cowbirds take no direct action against host young (see Hoffman [1929] in Ahlers and Tinsdale [1998] and Dearborn [1996] for possible rare exceptions). However, host species divert parental care from their own offspring to cowbird offspring. As a result, hosts nearly always experience some reduction in their own reproductive output. More explicitly, host losses are due to female cowbirds removing one or more host eggs from most nests they parasitize (Sealy 1992), to host egg damage by adult cowbirds (Peer and Sealy 1999) and to cowbird nestlings hatching before those of most hosts (Briskie and Sealy 1990, McMaster and Sealy 1998) and usually being larger (Friedmann 1963, Lowther 1993). The larger, more advanced cowbird nestlings often outcompete host nestlings for food brought to the nest by adult hosts although large host species usually raise some of their own young when parasitized. Small hosts with long incubation periods experience the greatest losses and willow flycatchers, in particular, usually lose all of their own young if a cowbird egg is laid during their laying period and hatches successfully (Sedgewick and Iko 1999, Whitfield 2000). For southwestern willow flycatchers, only 14% of 133 and 13% of 31 parasitized nests in California and 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). Lorenzana and Sealy (1999) have provided a recent review of the costs a range of cowbird host species incur when parasitized.

Robinson et al. (1993, 1995) provide comprehensive reviews of cowbird biology and impacts on hosts. Two extensive recent works on cowbird-host interactions and cowbird management are Morrison et al. (1999) and Smith et al. (2000). The latter volumes contain papers presented at two national workshops on cowbirds and their hosts in 1993 and 1997, each attended by at least 200 people (Holmes 1993, Rothstein and Robinson 1994). These two workshops have greatly expanded our knowledge of cowbird-host interactions and related management issues and the resulting volumes are essential reading for anyone contemplating cowbird management. Another recent useful reference is Ahlers and Tinsdale (1998), which provides an annotated bibliography of technical literature on cowbirds. Schweitzer et al. (1998) and Boren (1997) provide reviews of cowbird-host interactions and focus on southwestern willow flycatchers.

3. Cowbird Impacts on Host Populations

It is essential to keep in mind that although the individual hosts that are parasitized incur costs, such reductions in reproductive output do not necessarily have impacts upon host populations or entire species because density dependent processes, such as habitat availability, may limit passerine birds (Sherry and Holmes 1995). The decrease in recruitment to a host population due to cowbird parasitism may simply mean that fewer excess individuals die without producing young because they can not secure a breeding territory or because they can not find enough food to feed themselves. 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 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, there is no reason to believe that this limitation is any less natural than limitation by competition, habitat, nest predation or disease.

On the other hand, any factor that limits a species or subspecies that is rare is of course a source of concern, even if the factor is wholly natural. Thus even a moderate loss in recruitment due to parasitism may require management action for a rare species and especially for an endangered one. If parasitism is the only reason for a taxon's rarity, then long-term reduction of cowbird impacts is likely to be needed. However, all endangered passerines that appear to be affected adversely 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 likely in all cases that these endangered birds would be able to coexist with cowbirds if their habitat problems were remedied.

Besides a reduction in the total number of young produced, parasitism can also affect small host populations negatively by causing some host individuals to suffer complete failure. These failures reduce the number of adults that contribute offspring to succeeding generations. The latter number is known as the effective population size and population viability theory holds that as populations decline, there is an increasing risk that stochastic events and genetic factors will lead to extinction. Another potential cost of parasitism is the possibility that the extra parental effort needed to rear cowbirds and to renest after deserting parasitized nests reduces the subsequent survival of adult hosts. But a long-term study of the willow flycatcher found no evidence for such reductions (Sedgwick and Iko 1999).

Another potential impact of cowbirds is that they may depredate unparasitized nests to cause renesting by hosts with nests too advanced to be parasitized (Arcese et al. 1996). This cowbird predation hypothesis is based on a correlation between nest failure rates and cowbird presence in an island population of song sparrows (*Melospiza melodia*) in British Columbia and could mean that host populations suffer greater losses due to cowbirds than has previously been realized. If cowbirds manage host populations as predicted by the cowbird predation hypothesis, unparasitized nests should have higher predation rates than parasitized ones but no such overall trend has been found among nesting studies of cowbirds and their hosts (Rothstein 1975b, Kus 1999, Whitfield 1999). The hypothesis also predicts that nest predation should decline when host populations are protected by cowbird removal programs. But no such decline is evident for southwestern willow flycatchers, either among years with versus without cowbird removal (Whitfield et al. 1999) or within the same year between areas with and without cowbird removal (Whitfield 2000). There was also no marked change in predation of nests of another endangered species, Kirtland's warbler (*Dendroica kirtlandii*), 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.

There are direct observations of cowbirds removing nestlings and eggs and therefore acting as predators (Tate 1967, Scott and McKinney 1994) but this is also true for other passerines not regularly thought to be predators such as red-winged blackbirds (*Agelaius phoeniceus*), yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) and gray catbirds (*Dumetella carolinensis*) (Belles-Isles and Picman 1986, Sealy 1994, Cimprich and Moore 1995). Video documentation of predators at nests of two frequently parasitized host species showed that a cowbird was responsible for only one of 25 predation events at a Missouri study site where cowbirds were abundant (Thompson et al. 1999). Observations of removal of eggs or nestlings in Manitoba showed that cowbirds were responsible for five of 26 events. But none of the events involving cowbirds were clear cases of nest predation because only single eggs were removed in each case (Sealy 1994).

Recent studies by the same research group in British Columbia that proposed the cowbird predation hypothesis have produced results generally supporting the hypothesis for song sparrows (DeGroot et al. 1999, Arcese and Smith 1999). However, these recent studies have not determined whether heightened rates of nest failure associated with cowbirds are due to desertion of parasitized nests (a well known phenomenon) or to predation of unparasitized nests. With the present data available, we do not believe that cowbirds depredate unparasitized nests regularly enough to make this a management concern but additional research is needed.

4. Host Defenses Against Cowbird Parasitism

Besides its relevance to conservation biology, brood parasitism has long attracted the attention of biologists due to the opportunities it provides for studies of the evolution of adaptations that facilitate and deter parasitism by parasites and hosts (Rothstein 1990). These studies of parasite-host coevolution have shown that many species have evolved egg recognition in response to brood parasitism and selectively remove foreign eggs from their nests. In North America, such birds are known as rejecter species and nearly 100% of the individuals in their populations reject eggs unlike their own (Rothstein 1975a). Species that possess effective host defenses are unlikely to be impacted at the population level by cowbird parasitism. Most passerine birds in the Old World show some level of egg recognition (Davies and Brooke 1989, Moksnes et al. 1991, Nakamura et al. 1998) probably reflecting their long histories of contact with parasitic cuckoos of the subfamily Cuculinae (Rothstein 1994a). However, cowbird parasitism evolved much more recently than cuckoo parasitism (Rothstein et al. 2002)and only about 25 North American species are rejecters (Rothstein 1975a, Ortega 1998).

Most North American passerines are accepters in that they do not remove cowbird eggs placed in their nests and continue to incubate parasitized clutches. These species even incubate clutches consisting totally of cowbird eggs (Rothstein 1982, 1986). Recent work indicates that a small number of species that have cowbird-like eggs and that were previously classed as accepters actually manifest some degree of egg recognition when experimentally parasitized with eggs divergent from their own and from cowbird eggs (Burhans and Freeman 1997). It has long been known that although accepter species do not remove cowbird eggs from their nests, they often desert naturally parasitized nests and renest (Friedmann 1963, Rothstein 1975a, Graham 1988). This desertion/renesting response is not in response to cowbird eggs, because it is very rare after nests are experimentally parasitized by people (Rothstein 1975a,b) and is apparently in response to detection of adult cowbirds near or at nests (Burhans 2000). A recent synthesis of data from 60 studies on 35 host species showed that heightened desertion tendencies are likely to have evolved in response to cowbird parasitism. Desertion of parasitized nests is most likely in species that have broad habitat overlap with cowbirds and that experience high losses when they accept parasitism (Hosoi and Rothstein 2000).

However, even species with relatively high desertion rates often accept cowbird parasitism (Hosoi and Rothstein 2000) and parasitized individuals that fail to desert commonly suffer extreme reductions in reproductive output. Thus nest desertion, unlike egg ejection, is only partially effective as a host defense. As a number of recent studies on avian breeding biology have shown (Sedgewick and Knopf 1988, Pease and Gryzbowski 1995, Gryzbowski and Pease 1998, 2000; Schmidt and Whelan 1999, Woodworth 1999), the key metric of productivity for birds should be a female's seasonal output of young, not the more easily determined metric of productivity per nest. Because of renesting, the latter metric inflates the impacts of parasitism and nest predation. Southwestern willow flycatcher's desert about 35-57% of parasitized nests (Table 1). Thus the decline in willow flycatcher recruitment due to cowbird parasitism is something on the order of 43-65% of the parasitism rate, i.e., individuals that desert and then are not parasitized during a renesting attempt may experience little or no decline in reproductive output due to cowbirds. Similarly, many parasitized nests will be depredated and this too will often lead to renesting and an unparasitized nest. A small number of flycatchers build over parasitized nests and lay a new clutch in the same structure (Whitfield 1990), which is functionally similar to renesting.

Table 1. Desertion rates of parasitized willow flycatchers in different regions.

Subspecies	Region	New contact[1]	Parasitism rate (N[2])	Desertion rate (N[3])	Reference
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
extimus	Arizona	No	7% (203[4])	36% (14)	Paradzick et al. 1999
trailii	Colorado	?[5]	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

[1] Populations noted as yes under New Contact were allopatric with respect to cowbirds in pre-Columbian times.
[2] N reflects number of nests for which parasitism status (parasitized or unparasitized) could be determined.
[3] N reflects number of parasitized nests for which desertion status (deserted or not deserted) could be determined.
[4] Most of these nests were protected by cowbird trapping. Parasitism at two sites with no trapping was 0 of 8 nests (Alamo Lake) and 6 of 16 nests (Camp Verde).
[5] 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, and Chace and Cruz (1999) suggest that cowbirds occurred in the region in the 1800s before bison were nearly extirpated.

Desertion of a parasitized nest results in total failure for the nest and renesting incurs a risk that a willow flycatcher's new nest will also be parasitized. Nevertheless, desertion and renesting is nearly always the best tactic for parasitized willow flycatchers because it allows them to trade a 100% certainty of parasitism and little chance of producing any young of their own for a lesser chance of parasitism. However, while renesting may allow parasitized flycatchers that desert to raise as many young as unparasitized individuals, it could incur costs such as increased reproductive effort and late fledging of young, which could result in reduced survivorship of adults and young. But extensive analyses have found no clear evidence for such costs (Sedgewick and Iko 1999). For example, 48.9% of 92 parasitized female *E. t. adastus* returned in a subsequent breeding season compared to 55.2% of 255 unparasitized females, a difference that is not significant statistically. Among birds that were successful in fledging one or more flycatcher young, 72.0% of 50 parasitized females and 56.5% of 184 unparasitized females returned in a subsequent breeding season, a significant ($P < 0.048$) difference (Sedgewick and Iko 1999). The lack of detectable deleterious effects of breeding effort on adult willow flycatcher survival is a common result for passerines and only manipulative studies can address this issue adequately (Nur 1988). Sedgewick and Iko (1999) reported that the earliest fledged flycatchers (*E. t. adastus*) were significantly more likely to return to their study sites than were young that fledged in mid-season or later. Whitfield et al. (1999a) found that southwestern willow flycatcher young that fledged early in the breeding season were more likely to return to the South Fork Kern River than those that fledged later but the difference was not significant statistically. Another potential cost of desertion and renesting is that it may not allow birds enough time to engage in double brooding, which is the raising of a second brood after young from the first nest fledge. Paradzick et al. (1999) reported that 15 of 123 southwestern willow flycatchers in Arizona raised two broods in 1998. The extent to which renesting after parasitism deters attempts to raise second broods is unknown, but could have a small to moderate depressing effect on recruitment. Lastly, desertion of a series of nests, each of which is parasitized could leave a flycatcher with insufficient time to raise any young. However, the latter may be a rare occurrence because willow flycatchers continue to breed well after all or most cowbirds have stopped laying (below).

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 in an attempt 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. Heightened aggression towards cowbirds may even be maladaptive as cowbirds may use this host behavior to reveal nest locations (Smith et al. 1984).

5. Key Indicators of Impacts at the Population Level

The degree of lost reproductive output that individual parasitized members of a species incur and the parasitism rate (% of nests parasitized) are the two most vital parameters as regards impacts of parasitism at the population level. The timing and duration of a host species' breeding season are important determinants of parasitism rate. Cowbirds begin to breed later than some of their major hosts. Because early nests tend to have the greatest potential productivity, early breeding hosts 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 scarcity of other hosts species nesting late in the season. Thus cowbird impacts on willow flycatcher populations are potentially greater than on most host species. Late willow flycatcher nests are likely to escape parasitism completely because the cowbird laying season generally ends in early to mid-July (Stafford and Valentine 1985, Fleischer et al. 1987, Lowther 1993), although exceptional eggs have been laid into early August (Friedmann et al. 1977, p. 47).

As with all host species (Robinson et al. 1995a), parasitism rates on willow flycatchers are highly variable in space and time, both within a breeding season and across years. Even populations separated by only a few km may experience markedly different parasitism rates (Sedgewick and Iko 1999). Table 2 lists parasitism rates (for samples of 10 or more nests), in the absence of cowbird control, for populations from throughout the range of the southwestern willow flycatcher. Note that parasitism ranges from 29% to 66% for California sites, and from 3% to 48% for Arizona sites. Parasitism has the greatest impact on willow flycatchers in California because the largest population in that state consistently experienced rates of at least 50% in the absence of cowbird control. By contrast, the largest populations in Arizona (San Pedro River, Roosevelt Lake) and New Mexico (Gila River) have experienced mean yearly rates of 3% to 18% (Table 2).

Because of the large range in parasitism rates of the southwestern willow flycatcher, baseline nesting 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 management efforts directed at cowbirds. For example, the largest southwestern willow flycatcher population, in the Cliff-Gila Valley of NM, appeared to grow from 1997-1999 (Stoleson and Finch 1999; S. H. Stoleson pers. comm.) despite parasitism rates of 11% in 1997, 27% in 1998 and 16% in 1999. This population declined from 1999 to 2000 and was stable from 2000 to 2001. The parasitism rates in 2000 and 2001 were within the range seen in earlier years.

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 covered	No. nests	Mean annual parasitism rate
South Fork Kern R., CA	87, 89-92	163	66%
Santa Ynez R., CA[1]	95-97	17	29%[1]
Virgin R. delta, NV	97	14	21%
Grand Canyon, AZ	82-86, 92-96	25	48%
White Mtns., AZ	93-96	36	19%
San Pedro R., AZ	95-96	61	3%
Roosevelt Lake, AZ	95-96	17	18%
Verde R., AZ	96	13	46%
Verde R., AZ[2]	98	16	38%
Gila R., NM	95,97	49	18%
Gila R., NM[3]	97-99	>129[3]	18%[3]
various sites, NM	95	10	40%

[1] Data from Farmer (1999b). Parasitism rate is an overall one, not a mean for years covered.
[2] Data from Paradzick et al. (1999).
[3] Data from Stoleson and Finch (1999) and 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.

Given the temporal variability in the frequency of cowbird parasitism (Sedgewick 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 management if based on a reliable sample size free of temporal and spatial biases (see Management Recommendations, below). In addition, field workers can remove cowbird eggs from accessible parasitized nests (or addle them) during baseline studies to lessen the impacts of parasitism if there is concern about the persistence of a parasitized population. This sort of manipulation of parasitized nests has proven effective with another endangered cowbird host (Kus 1999), and is discussed in more detail below.

In reporting data on parasitism rates, workers should always include sample sizes if the intent is to represent region-wide impacts, i.e., the number of nests sampled and not just parasitism rates. Because of sampling error, parasitism rates based on small numbers of nests may have little statistical validity when it comes to assessing overall cowbird impacts, i.e., statements that parasitism can reach 100% may mean little if the 100% rate is based on a small sample. Baseline data on parasitism rates need to control for spatial and temporal variation in parasitism rates. For example, a sample composed of only early or late nests or of only nests from the periphery of a large habitat patch may not reflect overall parasitism rates. In addition, small populations may experience especially high parasitism rates that are not representative of larger ones (see below). However, if a small population is consistently parasitized heavily and if it has enough suitable habitat to allow significant growth, it may still be a good candidate for cowbird management, as discussed below under Management Recommendations.

6. Recent Changes That May Be Responsible For Possible Increases In Cowbird Impacts

The cowbird is a native North American bird with widespread fossils from California, Florida, Virginia, New Mexico and Texas dating from 10,000 to 500,000 years before the present (Lowther 1993). Data on DNA sequence divergence indicate that cowbirds have been in North America for at least 800,000 years (Rothstein et al. 2000). Because cowbirds represent an ancient component of the North American fauna, at least as regards ecological time scales, their impacts are unlikely to endanger host species in the absence of major ecological changes. One such change is a loss or deterioration of breeding habitat, something that is well recognized as the major cause of the southwestern willow flycatcher’s decline (Unitt 1987, U. S. Fish and Wildlife Service 1995) and of the declines of other endangered host species that are 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, which could cause a previously parasitized and stable host population to decline. Host populations that have only begun to experience parasitism due to documented cowbird range extensions in the last century might be especially likely to decline because they could lack evolved host defenses present in conspecific populations with long histories of parasitism. Given these considerations, trends in cowbird numbers and range extensions are important issues.

The first available historical records show the presence of cowbirds throughout the Southwest as far west as the Colorado River in the mid 1800s (Rothstein 1994b). These were members of the dwarf race of the cowbird, *M. a. obscurus.* The much larger Nevada race, *M. a. artemisiae,* occurred to the north of the southwestern willow flycatcher’s range in California, Oregon and Washington on the eastern slopes of the Sierra Nevada and Cascades mountain ranges and east to the northern Great Plains (Friedmann 1929, Rothstein 1994b). Dwarf cowbirds colonized southern California and all of the area west of the Sierra and Cascades since 1900. Thus parasitism is a new pressure only for southwestern willow flycatchers breeding in southern California.

However, cowbirds might be more common and more widespread today than under original conditions, even within their historical range. An analysis of parasitism rates of southwestern willow flycatchers showed large increases in data for California and Arizona combined (Whitfield and Sogge 1999). However, more analyses are needed to determine whether cowbird impacts have increased in the original contact zone in Arizona because the increasing trend in the lumped data for both states may have been driven by the cowbird’s increase in California. 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).

In contrast to the uncertainty concerning cowbird population trends over the last century, data from the Breeding Bird Survey (BBS) provide more reliable indicators of recent population trends. Averaged across North America, cowbirds have shown a significant decline of 1.1% per year since the inception of the Survey in 1966 (Sauer et al. 1997). Among 21 states and Canadian provinces with statistically significant ($P < 0.05$) increasing or decreasing cowbird numbers, 19 show declines and two increases. Fish and Wildlife Service Regions 2-5 show significant yearly declines of 0.7 to 2.7%. Region 1 shows a yearly decline of 1.6%, which is not quite significant ($P = 0.06$). Only Region 6 shows an increasing trend, 0.2% per year, but this trend is not close to significance ($P = 0.49$). Focusing on the states that contain the largest numbers of southwestern willow flycatchers, cowbirds have shown moderate declines in Arizona and California and a moderate increase in New Mexico (all trends nonsignificant statistically). These data refer to the entire period over which the BBS has been carried out. If data are partitioned by time, and states or provinces with positive or negative trends are tallied (regardless of whether trends for individual states/provinces are significant statistically), 25 of 51 states/provinces had negative trends from 1966-79 versus 37 of 52 from 1980-96. Significantly more states and provinces had decreasing cowbird numbers in the more recent period than in the first period ($X^2 = 5.26$, df = 1, $P = 0.02$). Thus cowbird numbers appear to have gone from no overall trend from 1966-79 to a mostly declining trend from 1980-96. Most recent BBS data for 1997 to 1999 show stable cowbird numbers in Arizona, California and New Mexico for these years. These various data are contrary to the widespread belief (Brittingham and Temple 1983, Terborgh 1989) that cowbirds are increasing over much of their range.

It is worth keeping in mind that even if cowbirds have not increased in recent years or since the 1800s (except in California), willow flycatchers and other riparian species have decreased, so increasing cowbird to host ratios may have resulted in escalated rates of parasitism even in areas of old sympatry between cowbirds and southwestern willow flycatchers. The potential phenomenon of 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 1999a, Tewksbury et al. 1999). This preference, along with the massive loss of riparian habitat in the southwestern willow flycatcher's range may mean that the numbers of cowbirds that use riparian habitat may be similar to those that prevailed years ago but that those cowbirds are now highly concentrated into the small remnants of remaining habitat, with consequent large increases in parasitism rates.

7. Can Southwestern Willow Flycatcher Populations Survive In The Presence of Cowbird Parasitism?

It is clear that most southwestern willow flycatcher populations are viable even when exposed to cowbird parasitism, at least under primeval conditions, because cowbirds and southwestern willow flycatchers have long been sympatric over most of the latter's range. Cowbird parasitism is a new pressure only for southwestern willow flycatchers in southern California. These latter populations might not be viable in the presence of cowbirds, regardless of environmental conditions, because they lack evolved defenses against cowbirds, as proposed for the least Bell's vireo, *Vireo bellii pusillus* (U. S. Fish and Wildlife Service 1998). However, the willow flycatcher's only evident defense against parasitism, renesting, is as frequent in southern California populations as in populations further east with longer histories of parasitism (Table 1). Because the latter willow flycatcher populations have coexisted with cowbirds, it is likely that newly exposed populations can also do so, unless they are experiencing a marginal existence even in the absence of parasitism.

Given what is known about rates of subspecific differentiation (Avise and Walker 1998) in birds, southwestern willow flycatchers have probably been undergoing genetic divergence and been at least partially isolated spatially from other willow flycatcher races for more than 200,000 years. Except for the last 10-20,000 years of this period, various species of bison, horses and other ungulates likely to serve as cowbird foraging associates have occurred throughout the range of the willow flycatcher, including southern California (Pielou 1991, Stock 1992). It is unlikely that the southwestern willow flycatcher had precisely the same range in the past as it does today but the ubiquitousness of large ungulates throughout North America (Pielou 1991), leaves little doubt that they and cowbirds occurred everywhere or most places willow flycatchers occurred. Thus it is likely that all southwestern willow flycatcher populations are descended from populations that experienced past episodes of cowbird parasitism and therefore selection for host defenses. 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, although gene flow from other parts of the flycatcher's range may also be a factor.

The occurrence and long term retention of high nest desertion tendencies in unparasitized populations is characteristic of North American hosts that use habitats similar to those used by cowbirds, namely woodland edges and fields rather than forest interior. Indeed, the degree of habitat overlap with cowbirds is a better predictor of desertion tendency than is current or recent degree of geographic overlap with cowbirds over historical time scales (Hosoi and Rothstein 2000). Another endangered riparian host, and one whose entire range has been occupied by cowbirds in this century is the Least Bell's Vireo. Kus (1999) reported that it deserted 29% of 205 parasitized nests, contrary to the widespread belief (U. S. Fish and Wildlife Service 1998) that it lacks defenses against parasitism. A study of Bell's Vireos in Missouri where the species has experienced cowbird parasitism since pre-Columbian times reported desertion at 59% of 66 parasitized nests (M. Ryan pers. comm.). It is unclear whether these different desertion rates reflect intrinsic differences in the California and Missouri vireo populations or differences in research techniques. Observed incidences of desertion are inversely proportional to the interval between nest checks (Pease and Grzybowski 1995) and nests were checked weekly in the California study but daily in the Missouri one.

Thus given adequate habitat and an absence of unusually severe demographic impacts such as high levels of nest predation and low levels of juvenile and adult survival, it is possible that all populations of these obligate riparian hosts, even ones newly sympatric with cowbirds, can remain viable if exposed to cowbirds. A demographic analysis of the southwestern willow flycatcher population along the Kern River, which is among the largest populations in California, indicates that this population can not grow unless parasitism is about 10% or less (Ueyahara et al. 2000). If a population cannot sustain itself in the presence of a 10% or less loss in recruitment, it must be a marginal one for reasons unrelated to cowbird parasitism. This same population was able to remain stable and possibly even grow from 1982-89 (Whitfield 1999) despite a 68% parasitism rate in 1987 (Harris 1991), the one year this rate was determined. Thus some critical variable, probably a decreaase in egg hatchability (Whitfield 2002), has changed in recent years. In short, data from extant populations and inferences based on the Pleistocene history of North America, indicate that all southwestern willow flycatcher populations can co-exist with cowbirds unless they also experience some new pressure such as severe habitat losses.

8. 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 no effect on the size of host breeding populations, even if it causes major reductions in host breeding success. But parasitism can push a host population or even an entire host species or subspecies to extinction under certain conditions. Furthermore, even if a local parasitized host breeding population is stable, parasitism may reduce the number of excess host individuals that might become floaters available to replace breeders lost to mortality or that might disperse and sustain other populations or initiate new populations. Nevertheless, there is no need to always attempt to reduce cowbird parasitism whenever it occurs. Cowbirds are native birds and as such are as important to biodiversity as are endangered species. 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 be out-competed by these species. Thus cowbirds could serve as keystone species (Simberloff 1998) just as do some predators that enhance biodiversity by reducing the numbers of certain prey species that would otherwise out-compete and cause the extinction of less competitive species.

Nevertheless, there are certainly some circumstances in which it is prudent to employ management actions designed to deter cowbird parasitism. The circumstances that should trigger cowbird management may differ from site to site because a number of potential site-specific factors are involved, including a host population's current size, its recent population trend, its parasitism rate, the 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. So first we review the range of management actions that may be available.

9. Potential Management Approaches

1. Landscape-Level Management

Cowbird distribution and abundance might be reduced to some extent by landscape-wide measures aimed at reducing 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. Besides livestock, cowbird feeding is often associated with other anthropogenic influences such as 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 the extent to which they associate with anthropogenic food sources depends on local landscapes. In the Eastern Sierra of California where most of the habitat is forests, sagebrush or arid, sparsely vegetated meadows, cowbird foraging is nearly always linked to human influences such as bird feeders, campgrounds, range cattle and pack stations (Rothstein et al. 1980, 1984; Airola 1986). A similar link with anthropogenic influences, has been found in other forested regions in the western (Tewksbury et al. 1999) and eastern U. S. (Coker and Capen 1995, Gates and Evans 1998). Cowbirds probably require anthropogenic food sources in these regions. But human influences and possibly even native ungulates are less essential for cowbirds in areas where mesic grasslands occur naturally, such as the Great Plains.

An essential factor in attempts to limit cowbird numbers on landscape scales is the cowbird's commuting behavior (Rothstein et al. 1984). In most regions, cowbirds spend the morning in areas such as forest edges or riparian strips that have large numbers of hosts. Their major actives in these habitats are related to breeding (e.g., egg laying, searching for nests, courtship and intrasexual aggression) but not feeding and birds occur singly or in small groups of up to several individuals. If these morning breeding areas are adjacent to or intermixed with good foraging habitat, cowbirds may spend their entire day in the same vicinity (Elliott 1980, Rothstein et al. 1986). But optimal feeding and breeding habitat are usually spatially separated and cowbirds typically leave their morning-breeding ranges by late morning to early afternoon and commute to feeding sites (Rothstein et al. 1984, Thompson 1994, Ahlers. and Tisdale 1999a), where large groups of several dozen birds may feed on concentrated food sources.

Several studies showed that the maximum commuting distance between morning/breeding and afternoon/feeding sites was 7 km (Rothstein et al. 1984, Thompson 1994, Gates and Evans 1998, Ahlers. and Tisdale 1999a), thereby implying that anthropogenic opportunities for cowbird feeding need to be at least 7 km from habitat critical of endangered hosts. However, a recent study in northeast New Mexico (Curson et al. 2000) has shown that a small proportion of female cowbirds have daily commutes of 14 km or more each way. Given the pervasiveness of human influence and these large distances over which cowbirds are known to fly between feeding and breeding areas, there may be few areas of North America where landscape-level management measures can completely eliminate local cowbird populations. Rather than complete elimination, cowbird abundance may at least be reduced by landscape-level actions because abundance has been shown to decline with increasing distance from anthropogenic food sources over distances as short as 2-4 km (Verner and Rothstein 1988, Tewksbury et al. 1999, Curson et al. 2000). Candidates for such areas are large expanses of desert or forested habitat with no human influences. Cowbirds may be adept at exploiting feeding opportunities even in regions where such opportunities are not evident to observers. An attempt to produce a region-wide decline in cowbird abundance in the heavily forested western Sierra Nevada by removing all cowbirds from horse corrals that attracted large numbers of birds had at best limited success because cowbirds also fed in small groups at other sites (Rothstein et al. 1987).

Effective landscape-level measures may be costly and time consuming given the likely economic impacts to agricultural and other interests that will occur if activities and facilities such as grazing and golf courses are curtailed. Furthermore, landscape-level measures may have only limited success in reducing parasitism rates. Therefore, although land managers should have long range goals that address landscape-level actions in regions where parasitism is a threat to host populations, effective results may require many years due to resistance from people whose economic and recreational interests are likely to be impacted. These long periods needed to produce benefits may not be acceptable for severely endangered hosts whose populations are strongly impacted by cowbirds and that need quick amelioration of cowbird impacts.

We know of only one landscape-level management action that seems to have been highly effective. Removing cattle from large areas of Fort Hood, Texas resulted in substantial reductions in cowbird numbers (Cook et al. 1998, Kolosar and Horne 2000). However, this was in a larger landscape setting in which cowbirds on adjacent areas with livestock or other foraging opportunities were controlled by extensive trapping and shooting (Eckrich et al. 1999). So removal of cattle might have been less effective if cowbirds had been present in normal numbers in surrounding areas thereby creating social pressures for individuals to disperse into the less desirable areas with no livestock.

2. Habitat alterations

Recent studies have indicated that the structure of riparian vegetation influences rates of cowbird parasitism or cowbird numbers. Parasitism rates and cowbird densities usually decline with increases in the density of vegetation (Larison et al. 1998, Averill-Murray et al. 1999, Farmer 1999a,b; Spautz 1999, Staab and Morrison 1999, Uyehara and Whitfield 2000), probably because nests are more difficult to find in dense vegetation. This relationship with vegetation density, which is not necessarily a universal result in cowbird studies (see Barber and Martin 1997), raises the possibility that cowbird parasitism might be reduced by measures that result in denser riparian vegetation, such as increased water flows (see Appendix I). However, as with landscape level management measures, attempts to increase the quality of riparian habitat may require periods of several years or longer for successful results. Given that habitat loss or degradation is probably the ultimate cause of the problems all endangered hosts face (Rothstein and Cook 2000), managers should vigorously pursue efforts to augment habitat. But endangered hosts severely impacted by parasitism may require actions that produce benefits more quickly.

3. Inhibition of cowbird breeding

A nonlethal method of limiting or eliminating cowbird impacts on hosts might be to inhibit their breeding. Yoder et al. (1998) reviewed the literature on avian contraceptives. They report that several compounds can be delivered via baited food and therefore might be administered to large numbers of birds. But these all have various problems. Some compounds are environmental hazards. Others keep eggs from hatching but allow breeding and would therefore not avoid host loses due to adult female cowbirds. The most promising compound, DiazaCon prevents egg laying and also inhibits fertility in males but must be administered over a 7-14 day period with available modes of delivery. Currently, there is no feasible method of inhibiting breeding of a large proportion of a local cowbird population but this approach is worthy of additional research.

4. Cowbird control

Although altering local landscapes or habitats to reduce cowbird impacts should be long-term management goals, local cowbird populations can often be quickly and easily reduced by intensive trapping efforts. The species is highly social (Rothstein et al. 1986) and is attracted to decoy traps, which can remove most cowbirds from large areas where willow flycatchers and other endangered hosts breed (Eckrich et al. 1999, DeCapita 2000, Griffith and Griffith 2000). These traps are referred to as decoy traps because the vocalizations and even the sight of live decoy cowbirds in the traps, along with food such as millet, attract wild cowbirds (see Dufty 1982, Rothstein et al. 1988, 2000), which then enter through small openings. Trap openings are generally on the tops of the traps and birds walking on the traps enter easily by folding their wings against their bodies and dropping into traps. Escape is difficult because birds cannot fly through the openings and traps are built so as to ensure that no inside perches are near the openings.

In addition to trapping, 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 (Hall and Rothstein 1999). However, removing or addling cowbird eggs does not recover host egg losses inflicted by adult cowbirds and can not be done at nests too high to be reached. Addling cowbird eggs by shaking them may be preferable to removing cowbird eggs because birds like the willow flycatcher that do not remove cowbird eggs from their nests come to consider cowbird eggs as part of their clutch. Willow flycatchers will even incubate clutches consisting solely of cowbird eggs (M. Sogge pers. comm.). Accordingly, they will desert if the combined volume of eggs is reduced below a certain value by removal of cowbird eggs (Rothstein 1982; Kus 1999). Indeed a close relative of the willow flycatcher, the eastern phoebe (*Sayornis phoebe*) is more likely to desert a nest after cowbird eggs are removed than after its own eggs are removed because the larger cowbird eggs make up more of the combined clutch volume (Rothstein 1986). On the other hand, there may be situations in which a parasitized flycatcher is better off deserting a nest because renesting will allow it to recoup those of its eggs that were lost to damage and removal by female cowbirds. In such cases, it may be best to remove all eggs to induce renesting and to place any viable willow flycatcher eggs in active unparasitized flycatcher nests at a similar stage of incubation. However, there are many factors to consider in such manipulations and few researchers are likely to have the experience necessary to make appropriate decisions. Anyone contemplating such manipulations will need to consult with the Fish and Wildlife Service and obtain permits in addition to those usually needed for study of southwestern willow flycatchers.

Shooting cowbirds and removal/addling of cowbird eggs may be more cost effective and practical than trapping if cowbird and/or local host numbers are low and if experienced personnel are available. These latter measures may also be better options than trapping if an impacted host population is in a remote or rugged area where the set-up and servicing of traps is difficult (Winter and McKelvey 1999). But cowbird trapping is likely to be the most effective management action in most situations.

Cowbird trapping efforts are typically highly successful in reducing parasitism rates. Parasitism is usually reduced from 50% or higher to below 20% and sometimes much less (Table 3). Increases in host reproductive output are well documented for four endangered species (Table 3), although this is on a per nest basis in some cases rather than a per female/season basis. Cowbird trapping was highly successful in boosting southwestern willow flycatcher reproduction along the South Fork of the Kern River. The mean number of young each female fledged per season went from 1.04 before control to 1.88 afterwards (Table 3).

Table 3. Summary of results of major cowbird control programs. Data shown are values for years before--after control.

Host species	Locality	Years	Parasitism rate	Young per female[1]	Nest success[2]	Host increase?[3]
Sw WIFL[4]	California	89-91--94-97	63%--17%	1.04--1.88	23%--43%	No
BCVI[5]	Texas	87-88--91-97	91%--22%	----	9%--40%	Yes
LeBEVI[6]	California	82--84-91	47%--6%	1.33--2.79	----	Yes
KIWA[7]	Michigan	66-71--72-77	70%--6%	0.80--3.11	----	No[7]

[1] Number of young fledged over entire breeding season.

[2] % of nests fledging one or more host young.

[3] Column refers to whether the host showed an increase in breeding population size within 5 years of the initiation of cowbird control.

[4] Southwestern willow flycatcher. Data reported (Whitfield et al. 1999) are for years with no cowbird control (1989-91) and with intensive control (1994-97). Intervening years (92-93) had intermediate levels of control and intermediate values for most parameters.

[5] Black-capped vireo. Data reported (Eckrich et al. 1999; Hayden et al. 2000) are for years with little or no cowbird control (1987-88) and years with extensive and well developed control (1991-97). Even within the latter period, personnel have improved methodology, e.g., parasitism rate ranged from 26-39% in 1991-93 and from 9-23% in 1994-97. Nest success data cover only up to 1994, when it had risen to 56%.

[6] Least Bell's vireo. Data reported (Griffith and Griffith 2000) are for a year (1982) with no cowbird control and for years (1984-91) with extensive and well developed control. Trapping intensified over the latter years, with the parasitism rate close to zero and the young per female 3 or more since 1989.

[7] Kirtland's warbler. Data are from DeCapita (2000). This species began to increase about 18 years after cowbird control began.

Unfortunately, the efficacy of control efforts is difficult to assess 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). The latter action deviates from proposed guidelines for cowbird management (U. S. Fish and Wildlife Service 1991, 1992; Robinson et al. 1995a, Whitfield and Sogge 1999, this paper) but might be justified if a local population or an entire metapopulation appears to be in danger of imminent extinction. That is, in some cases, cowbird control may be the only short-term option for increasing willow flycatcher productivity in populations on the edge of extirpation.

Although the productivity of host nests has increased markedly in all cowbird control efforts, cowbird management has a mixed record (Table 3) when it comes to the ultimate measure of success, namely 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 in some or all cases to assess the extent to which other management actions, such as improved and expanded habitat, have contributed to the increases. In addition, a key population of the least Bell's vireo (the northernmost in the taxon) declined after cowbird trapping began (Rothstein and Cook 2000), although this is largely attributed to habitat maturation and an associated reduction in suitability (J. Greaves, J. Uyehara pers. comm.). Kirtland's warbler and willow flycatcher populations did not increase in response to cowbird trapping. Trapping may have forestalled further declines in these latter species (DeCapita 2000, Whitfield et al. 1999, 2000) but Rothstein and Cook (2000) argue that the evidence for such effects is far from conclusive. The Kirtland's warbler began to increase dramatically about 18 years after trapping began but only after large amounts of new breeding (DeCapita 2000) and wintering habitat (Haney et al. 1998) became available, although the importance of wintering habitat is in some dispute (Sykes and Clench 1998).

Focusing on the willow flycatcher, cowbird trapping since 1993 has not resulted in population increases in the Kern River Valley. Instead the population has declined from 34 pairs in 1993 to 23 in 1999 and was down to 12 and 11 pairs, respectively, in 2000 and 2001 (Whitfield 2002). A demographic analysis indicates that control needs to be even more intense and that parasitism needs to be reduced from the present 11-19% to < 10% for this population to increase (Uyehara et al. 2000). If this is indeed the case, then other factors affecting this population need to be identified as the population would barely be replacing itself even in the absence of cowbird parasitism. Nor did this demographic model predict the sharp decline in 2000. It is likely that the Kern population has a low rate of nest success relative to other populations of the southwestern willow flycatcher (Stoleson et al. in press). This low rate may relate to recently elevated levels of hatching failure starting in 1997 due to an increased incidence of inviable eggs, 3.0% before 1997 versus 13.1% for 1997 to 2001 (Whitfield and Lynn 2001, Whitfield 2002). However, the population remained stable from 1993 until 1997 when cowbird trapping occurred while hatching rates were at normal levels. Also, as discussed above, the South Fork Kern River population grew or remained stable in the 1980s even though there was no cowbird control then.

Cowbirds have been controlled at Camp Pendleton since 1983 as part of management actions to recover the least Bell's vireo (Griffith and Griffith 2000). Although there was an early report of a modest increase in willow flycatchers as of 1991 (Griffith and Griffith 1994), the population later declined despite intensified cowbird trapping and overall there has been no marked increase in flycatchers as of 2000 after 18 years of cowbird control. It is possible that there may not be sufficient habitat at Pendleton for willow flycatcher population growth but the increase in the riparian obligate Bell’s vireos from 60 to over 800 pairs suggests that there might be at least some unused flycatcher habitat on the base. Because it is designed to protect least Bell's vireos, cowbird trapping at Pendleton ends well before the willow flycatcher breeding season ends so it is possible that the willow flycatcher population there has not been sufficiently protected from parasitism. However, this is unlikely because trapping data show that nearly all cowbirds are removed in the first half of the trapping period, and no parasitism of willow flycatchers has been detected since nest monitoring began in 1999 (Griffith Wildlife Biology 1999, Kus et al. in prep.). Only minimal numbers of cowbirds remain when willow flycatcher breeding begins in June (Griffith and Griffith 2000). 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) that breed there (Pike et al. 1997).

Trapping programs to protect flycatchers began in 1996 and 1997in Arizona (Table 4). No baseline data on parasitism rates were collected and local flycatcher habitat was not completely surveyed at some sites before trapping began. These problems, along with subsequent increases in survey area and effort at most sites and increases in suitable habitat at some sites, make it difficult to assess effects of cowbird control. 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 of 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 before control began; although it may have already been at dangerously low levels (Table 4).

Table 4. Numbers of southwestern willow flycatcher pairs counted at Arizona sites before and after cowbird control began. 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).

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

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

[2] **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.**

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

Data from a New Mexico site, San Marcial, along the Rio Grande River show no clear effect of cowbird trapping on flycatcher population size. In the absence of cowbird trapping, this site had six flycatcher nests in 1995 (all data were reported in terms of numbers of nests not pairs). Cowbird control was carried out in 1996, 1997 and 1998 with the following numbers of nests in each year: one, two and two, respectively (Robertson 1997, Ahlers and Tisdale 1998b, 1999b). The small numbers of flycatchers breeding at this site may mean that stochastic effects are overwhelming any benefits derived from cowbird control.

10. Is Cowbird Control A Longtime Or Even Permanent Need?

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, as all studies show that it has either no effect on cowbird numbers in subsequent years (Eckrich et al. 1999, DeCapita 2000, Ahlers and Tisdale 1999, Griffith and Griffith 2000) or too small an effect to negate the need for yearly trapping (Whitfield et al. 1999). Cowbird control efforts are often done with little care to maintaining constant procedures and possibly even with incomplete record keeping from year to year, so long term effects on cowbird populations are hard to judge in some cases. Indeed, the state of Texas encourages landowners to trap cowbirds and does not require trappers to report information on the numbers of cowbirds killed (Texas Parks and Wildlife pamphlet). This is unfortunate because it will be impossible to assess whether such actions have any long-term effects on cowbird numbers and even whether they benefit the targeted host species in the absence of record keeping and suitably designed control programs.

Even though 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 to a rare host whose endangerment is due in part to parasitism. If a small host population grows and becomes large as a result of cowbird trapping and possibly other measures, it may experience parasitism rates that are much lower than when it was small. Small host populations may experience high rates of parasitism because they provide few nests for cowbirds to parasitize. But once small host populations have grown, they may experience much lower rates of parasitism because a similar number of cowbird eggs may be dispersed amongst a larger number of nests. These lowered parasitism rates would be similar to the well-known effect that increased numbers of prey have on predators. Just as increased prey numbers may swamp out the per capita risk of nest predation, so too may increased host numbers lower the per capita risk of parasitism. These lower rates of parasitism may have no impact on host population dynamics. Parasitism will not decline if increased numbers of an endangered host result in commensurate increases in cowbird numbers. But given the extent to which some endangered hosts have increased, such as the more than ten-fold increase in Bell’s vireos on Camp Pendleton, it is unlikely that cowbirds would show commensurate increases.

The hypothesis that parasitism rate is inversely proportional to host population size views small host populations as ecological traps that can result in local extinctions due to parasitism. It further views the need for protection from parasitism as essential only until a population becomes large. The hypothesis is compatible with Spautz's (1999) discovery that parasitism rates of common yellowthroats (*Geothlypis trichas*) at sites in the Kern River Valley were inversely proportional to this host's density although other factors may also be involved. The best test of the hypothesis would be achieved by ending trapping, at least temporarily, for host populations that have grown to be large, such as least Bell's vireos at Camp Pendleton or Kirtland's warblers in Michigan and monitoring parasitism rates for two or more years. A temporary cessation of cowbird control would reveal whether parasitism rates are lower than they were with much smaller host populations and whether cowbirds show increases commensurate with those of the targeted host. Although it may be difficult to change current management policies, a temporary halt to cowbird control would be of considerable interest to researchers concerned with basic ecological mechanisms. It could also have high management value because considerable resources would be saved if results show that parasitism rates are so low that yearly cowbird control is no longer necessary.

11. Conclusions Regarding Cowbird Management Methods

In addition to the discussion presented here, Ortega (1998:279) provides a useful discussion of management actions that might lessen cowbird impacts. Management measures such as landscape level alterations in human land use patterns or increases in vegetation density are appealing because they are likely to have long lasting effects on cowbird parasitism and do not involve massive killing of a native songbird. However, we suggest that cowbird trapping seems to be the only viable management measure for most situations involving hosts that are endangered by parasitism. Trapping reduces parasitism levels and does so immediately. Moreover, trapping may need to be carried out for only a limited number of years if it boosts a host's population size and if increased host numbers alone reduce parasitism rates, as described above.

By contrast, landscape level measures may take years to institute and may be impossible in many to most areas given the extent to which humans have altered North America in ways that benefit cowbirds. Similarly, increased vegetation density takes time to develop and may be difficult to achieve in arid areas of the Southwest where water is scarce and likely to become more scarce given the high rate of human population growth in this region. It is likely that any increases in vegetation will benefit endangered hosts much more by increasing the amount of breeding habitat than by direct effects on levels of parasitism. For further discussion of riparian restoration techniques, see Appendix K.

Here we focus further discussion of cowbird management on trapping programs, although we stress that there is as yet no evidence that cowbird trapping results in increases in the breeding population sizes of southwestern willow flycatchers (as discussed above). We further stress that increases and improvements in host breeding habitat should always accompany cowbird management efforts because habitat is a limiting factor for all endangered species impacted severely by cowbird parasitism (Rothstein and Cook 2000) and cowbird control alone is a stop gap measure (U.S. Fish and Wildlife Service 1995). Similarly, regulators should never be satisfied with mitigation under the Endangered Species Act or other management approaches that involve only cowbird management and no attention to habitat augmentation. And they should give careful scrutiny to long-term management plans or actions that are focused mostly on cowbird trapping, even if the plan gives some attention to improving or increasing a host's habitat. Nevertheless, if cowbird parasitism is indeed a limiting factor for an endangered species given the amount of currently available habitat, agencies may have to commit to a number of years of cowbird trapping, with the length of the period determined by criteria in Management Recommendations 3 and 6 (below).

Although trapping is likely to be the most efficacious management tool for reducing unacceptably high cowbird impacts, three caveats are necessary. First, it may not be necessary to carry out trapping indefinitely, much less the trapping in "perpetuity" advocated for the least Bell's vireo in its draft recovery plan (U. S. Fish and Wildlife 1998). The putative need for trapping in perpetuity seems to be based on the mistaken belief (above) that least Bell's vireos cannot withstand any level of cowbird parasitism due to a lack of defenses, even though conspecific populations long exposed to parasitism have been able to coexist with cowbirds. In addition, the need for trapping will be reduced or eliminated if enlarged host populations alone result in lowered parasitism rates, as described above. Secondly, although trapping is likely to be the most effective management tool in most situations in which cowbirds threaten the survival of flycatcher populations that are otherwise viable, managers need to be flexible regarding alternative approaches. Some host populations may be in areas that are so remote and far from roads that it may be difficult to use the large decoy traps that are effective for cowbird trapping. In such cases, it may be more cost effective to shoot cowbirds after they are attracted to female chatter calls (Eckrich et al. 1999, Rothstein et al. 2000) and/or to monitor host nests and remove or addle cowbird eggs in nests that are accessible to field workers (Kus 1999, Winter and McKelvey 1999). Similarly, if a host population is very small, it may be most cost effective to monitor all nests even if trapping is feasible. Although nest monitoring and removal or addling of cowbird eggs avoids the major losses incurred by cowbird nestlings, it cannot recover egg losses due to the actions of adult cowbirds. On the other hand, trapping alone may not remove all adult cowbirds and therefore some nests may still be parasitized. Our last caveat is that, even if trapping is eventually shown to be effective in boosting southwestern willow flycatcher population sizes, managers may find it cost effective and biologically effective to leave some small and or remote host populations unprotected and divert the scarce management funds thereby saved to other actions. With these caveats in mind, this document next addresses the potential benefits and downsides of cowbird control (achieved largely by trapping), at least as it is currently conducted.

12. Potential Pros and Cons Of Cowbird Control

Although the list of potential downsides of cowbird control is longer than the list of potential benefits, choosing whether to control cowbirds should not be a matter of tallying up a score. If the first benefit listed below occurs, an increase in an endangered species' breeding population, it alone is likely to outweigh all negative aspects put together and therefore dictate making control efforts a high priority, at least for a number of years. Although it is currently unclear as to whether cowbird control increases southwestern willow flycatcher breeding populations, more definitive data may be available in several years.

As regards the potential positive and negative aspects of cowbird control, it is also worthwhile to recognize that some managers might not agree that each benefit we have listed is in fact a benefit or that each downside is in fact a potentially negative aspect of cowbird control. But we have chosen to list all of these points so that managers can be as well informed as possible regarding the consequences of cowbird control. We also point out that some of the downsides of control are not inherent in the control methods but may or do occur in some circumstances because of the manner in which control is done.

1. Potential Benefits or Positive Aspects of Cowbird Control

a) Cowbird control appears to have resulted in large increases in the populations of least Bell's vireos and black-capped vireos and this might eventually be shown to be true for the southwestern willow flycatcher as well.

b) Cowbird control clearly increases the reproductive output of willow flycatchers and other hosts. Even if the numbers of breeders in a population protected by control do not increase, perhaps because of limited breeding habitat, control may lessen chances of extinction by increasing the numbers of individuals that colonize other habitat patches or that become floaters, i.e., sexually mature birds capable of breeding but kept from doing so by a shortage of habitat.

c) Cowbird control may have stalled a decline in willow flycatcher numbers along the South Fork of the Kern River in the early 1990s and may have forestalled the extinction of the Kirtland's warbler.

d) Cowbird trapping is easy to do, although ease of application should not itself be used as a reason for choosing to trap cowbirds.

e) Cowbird control may benefit other sensitive species in addition to an endangered species that is targeted for management action.

2. Potential Downsides or Negative Aspects of Cowbird Control

a) Control has to be done every year or at least for sustained periods due to the failure of trapping to sufficiently reduce cowbird numbers in subsequent years.

b) Control has yet to result in an increase in a willow flycatcher population, although sufficient data are not yet available for Arizona willow flycatcher populations where trapping began in the last several years.

c) When cowbird trapping is not needed or has minimal benefits, trapping uses money/resources that could be used for management/research efforts that might result in greater benefits for endangered hosts such as the willow flycatcher.

d) Trapping might result in cowbirds developing either learned or genetic resistance to trapping. An unknown number of cowbirds escape from the decoy traps commonly used to catch cowbirds (S. Rothstein pers. obs.) and some cowbirds appear to be reluctant to enter these traps (M. Whitfield pers. obs.). Cowbirds at long-term Sierran study sites eventually learned to associate Potter traps with danger and flew off at the sight of people carrying these traps (S. Rothstein and others, pers. obs.). Trapping exerts potential selection pressures of enormous strength on cowbird populations and the potential problem here is akin to the well-known tendency of pathogens to evolve resistance to antibiotics. Just as antibiotics should be used only when really necessary, cowbird trapping too should only be employed when it is clearly justified.

e) Because it is easy to do and results in easily cited numerical indicators (e.g., numbers of cowbirds killed, increases in willow flycatcher productivity), cowbird control (usually via trapping) can be used by developers, other private interests or governmental agencies to show that endangered species are being aided or that legally mandated mitigation obligations for adverse impacts are being met, even if cowbird trapping results in little or no actual mitigation or host benefits. It is especially unfortunate if cowbird control is used as mitigation under the Endangered Species Act in the absence of baseline data needed to determine the level of cowbird impacts. Control should never be the sole mitigation measure for habitat destruction of an endangered species. If the availability of ocntrol as a mitigation measure in consultations with governmental agencies allows or legitimizes actions that result in habitat loss, a local flycatcher population may suffer greater detriment than if cowbird control had not been considered as a mitigation option (especially if cowbird parasitism was not a major impact).

f) There are ethical and animal care issues related to cowbird control, especially if the need for control has not been adequately justified. Importantly, excessive trapping efforts that are not justified could create challenges to the use of cowbird trapping and thereby jeopardize the potential to use this approach when it is justified.

g) Personnel involved in cowbird trapping efforts may not be researchers and may provide insufficient documentation, although if the latter occurs, the fault lies ultimately with the supervising agency. Another potential personnel problem relates to the fact that cowbird trapping efforts in the West are often contracted out to private consulting firms. Because of profit incentives, some private parties may lobby unduly for continued or expanded trapping efforts and there may be no motivation for contractees to suggest cost saving changes in trapping methods. Even cowbird control done by governmental agencies may have some momentum towards expansion or continuance because stopping control for a year or more might make it difficult to acquire funds if it appears that control needs to be reinstated.

h) Cowbird control is sometimes initiated without sufficient baseline data to assess cowbird impacts which means that there may be no basis for determining whether the action is having beneficial population level effects on hosts. In the absence of any data on effects, there may be little insight as to decisions about ending control and directing resources towards other goals.

i) Cowbird control without sufficient baseline data could retard some components of the overall effort to recover endangered species such as the southwestern willow flycatcher because vital baseline data on such things as parasitism rates needed for population viability analyses (PVA) may not be available (although the increased numbers of young could result in more data on dispersal, an essential element in most PVA models).

j) Cowbird trapping results in the capture of non-target species. For example, there were 8,453 captures of about 1,500 individuals of non-target species during cowbird trapping efforts at the Camp Pendleton Marine Corp Base in 1994 (Griffith and Griffith 1994). Most species do poorly when left in traps and individuals often die within 24 h or less. Even if non-target birds are released promptly, time spent away from their nests may result in reproductive failure.

k) Because cowbird control constitutes human intervention, it is uncertain whether willow flycatchers can be removed from the endangered species list as long as control continues.

l) Cowbird control constitutes active management intervention and might therefore deter attention from other types of intervention, such as actions that reduce the impacts of nest predators. Because nest predation is usually as harmful to willow flycatcher population growth as is cowbird parasitism or more so, we provide a brief discussion of predation and of possible management actions in an appendix to this paper.

13. Recommendations For Cowbird Management

Managers need to be flexible in their approaches and should not adopt the view that cowbird trapping is one of the very first things that should be done as soon as a willow flycatcher population or a population of any endangered species impacted by cowbirds is identified. Similarly, managers should not adopt cowbird trapping just because funding becomes available for a particular site and regulators should not restrict available management funds to cowbird trapping simply because this is an easily executed action. An endangered host may benefit more in the long run by first using funds to monitor interactions between cowbirds and the endangered host because the data collected may show that the funding will be of more benefit if applied to management actions other than cowbird control. Trapping should be instituted only when baseline data justify its use, as indicated below. Lastly, managers should also address other factors that reduce passerine nesting success, such as nest predation (see Appendix to this paper).

More specifically, our recommendations regarding cowbird management are as follows:

1. Increase the amount and quality of riparian habitat.

Regardless of whether cowbird management actions are undertaken, and what form those actions might take, managers should strive for increased amounts of riparian habitat. Consideration of endangered host species across North America shows that a shortage of breeding habitat (or poor habitat quality) is always a major problem or the major problem if cowbird management is contemplated. Although endangered hosts may have large amounts of habitat in some localities, the amount, and often the quality, of habitat summed over a species' range is considerably less than under original conditions in all cases. Increased amounts of high quality habitat and increased patch sizes of such habitat will allow for larger breeding populations of willow flycatcher and other species. These larger populations are likely to experience reduced levels of cowbird parasitism by dispersing cowbird eggs over a larger number of nests. In addition, larger populations are more resistant to extinction for a range of well-known reasons. Due to their relatively larger amounts of interior habitat, large patches of riparian woodland are likely to further reduce cowbird parasitism and nest predation, both of which tend to be concentrated along habitat edges in some regions (Robinson et al. 1995b, Tewksbury et al. 1998, Farmer 1999b). Measures to increase the quantity and quality of riparian habitat are discussed in Appendices G (grazing management), H (exotic species), I (water management), K (habitat restoration), and L (fire management).

2) Initiate cowbird control to protect a particular flycatcher population only after sufficient baseline data show cowbird parasitism to be a significant threat for that population.

Cowbird control to aid local willow flycatcher populations and other rare/endangered hosts should be instituted only after baseline data show parasitism rates to be above a critical level. The need for baseline data is in accord with recovery plans for other endangered southwestern hosts. Recovery plans for the black-capped vireo and golden-cheeked warbler, *Dendroica chrysoparia* (U. S. Fish and Wildlife Service 1991, 1992) recommend at least two years of baseline data to determine whether cowbird control is warranted. If control is instituted, managers should consider it a stop gap action (U. S. Fish and Wildlife Service 1995) and have a long range goal that includes restoring flycatcher populations to conditions that no longer require cowbird control. Robinson et al. (1993, 1995) discuss conditions that should be addressed in a management decision concerning cowbird trapping and Smith (1999) makes explicit recommendations regarding levels of parasitism that should initiate consideration of cowbird management actions. In general, Smith suggests that management should only be considered if parasitism is > 60% for two or more years but lists a number of considerations that dictate raising or lowering this threshold. In particular, he recommends that the critical parasitism level for management considerations be lowered to >50% if a species is listed as threatened as endangered. Given the southwestern willow flycatcher's low numbers, we suggest that cowbird control should be considered if parasitism exceeds 20-30% after collection of two or more years of baseline data. But even our guidelines must be applied with flexibility that gives weight to available data on local populations, i.e. sites need to be treated individually. An important consideration should be current population trends. For example, there has been a decline in the willow flycatcher population at the South Fork Kern River since cowbird control began, despite a reduction in parasitism rates from 65% to 11-20% from 1994-99 (Whitfield et al. 1999, Whitfield unpubl. data). This decline is in accord with demographic evidence indicating that this population cannot sustain itself if parasitism exceeds 10% (Uyehara et al. 2000), so current data clearly warrant a 10% threshold for this population. However, other populations such as at the Cliff-Gila one in New Mexico increased between 1997-1999, despite parasitism rates ranging from 11-27%, and for them parasitism rates of 30% or even higher may not warrant cowbird control. Monitoring nests to collect baseline data needed to determine whether control is needed can be costly but trapping and other control methods are also costly. Moreover, collection of baseline data could easily 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, all populations with more than five nests should be monitored. If available funds allow attention only to some small populations, managers should give higher priority for both control and monitoring nests to populations that are not limited by habitat availability. Cowbird eggs should be removed or addled during years when nests are monitored to determine parasitism rates, unless a population is part of an experiment designed to test whether cowbird trapping alters flycatcher population trends. Although a single parasitism rate that triggers the initiation of cowbird control, rather than a range that spans 20-30% (or even more, see above), would make management decisions easier, it wouldn't necessarily make those decisions better. Rather than adhering to the upper or lower end of the suggested range, managers and regulators should make adaptive management decisions that take into account other important factors in addition to parasitism rates. Such factors are a population's current trend (increasing, stable or decreasing), the potential for growth afforded by a population's current and anticipated habitat availability and whether control is the best use of management funds. There are complex scientific issues to assess, and managers and regulators should consider consulting with members of the USFWS Southwestern Willow Flycatcher Technical Recovery Team or other scientists.

3) When a cowbird control program is initiated, define goals that will lead to a successful completion of the program and plan for periodic, 3-5 year, peer reviews to judge the program's efficacy.

If a cowbird control program is begun, the following actions should be codified as part of the control program: a) a program of periodic reviews, every 3-5 years, by scientists who are not involved in the control program but who will assess the program's efficacy (as regards increases in the sizes of willow flycatcher breeding populations); b) a statement of goals that define conditions that will end the control program; c) provisions for a nest monitoring program for at least 3-5 years after control ceases (and at several year intervals after that) to determine whether parasitism rates exceed acceptable levels as defined in Recommendation 2 (see also Recommendation 6); d) a commitment to seek new funding if cowbird control needs to be reinstated after a period without control. Conditions that would result in cessation of control under item b for a particular flycatcher population include, but should not be limited to, removal of the southwestern willow flycatcher from the endangered species list.

4) Because current cowbird control programs have not yet resulted in increased numbers of southwestern willow flycatchers, design overall control programs as experiments that have the potential for critical assessments of the efficacy of this management approach.

Current control programs may have little or no potential to demonstrate that cowbird control affects willow flycatcher population sizes, regardless of the trends that ensue after control is instituted, because multiple factors are being altered, as is usually the case in the management of endangered species. Available evidence from the Kern River flycatcher populations (Whitfield et al. 1999) indicates that cowbird trapping does not result in increases in the breeding populations of southwestern willow flycatchers. Therefore, trapping efforts should be designed in part as experiments that can determine whether cowbird trapping increases willow flycatcher populations. To accomplish this, populations with cowbird control should be compared with a limited number of similar populations that have no cowbird control. Populations with and without control should be chosen so as to be as similar as possible as regards such parameters as size and recent population trends. Such experiments will mean that cowbird control is not instituted in all willow flycatcher populations that appear to need it under the conditions laid out in Recommendation 2. All willow flycatcher populations with no cowbird control should be monitored for parasitism rates and control should be instituted if there is clear evidence that parasitism threatens survival of the population.

5) Cease cowbird trapping at selected southwestern willow flycatcher populations to allow collection of baseline data and to provide populations without cowbird trapping for the balanced experiment (Recommendation 4) designed to test the efficacy of cowbird control.

Cowbird trapping should be stopped at selected willow flycatcher populations to allow collection of baseline data on flycatcher nesting biology (cowbird parasitism rates and other factors affecting flycatcher productivity, such as egg hatchability, nest predation, etc.) and to provide populations without cowbird trapping for the balanced experiment (Recommendation 4) designed to test the efficacy of cowbird control. After collection of at least two years of baseline data, an adaptive management decision should be made as to whether control needs to be reinstated, as defined under Recommendation 2. However, a limited proportion of populations that meet the conditions for control should become part of the no trapping sample for the balanced experimental studies described in Recommendation 4. Such populations should be selected on the basis of the criteria described under Recommendation 4.

6) Determine the need for continued cowbird control once a southwestern willow flycatcher population has grown to be large.

Cowbird control should be stopped after a local willow flycatcher population reaches a large size because the increased numbers of willow flycatchers may experience a level of parasitism, even in the absence of cowbird control, that is much less than the level that occurred when the population was small, as described above. But qualified researchers should monitor such populations to determine whether parasitism rates are at tolerable levels as defined under Recommendation 2. Because we do not at present know the extent of reduction in parasitism rate as the population of an endangered host increases, we can not precisely determine how much increase a population must show before its enlarged size results in a significant reduction in parasitism rates. Instead, we suggest that a population that is at least two or three times as large as it was when conditions justified initiation of cowbird control should be considered for cessation of cowbird control so long as the increased population has an absolute number of pairs equal to or exceeding 25. A two to three fold increase in flycatcher population size could reduce parasitism rates to one half or one third of their pre-cowbird control levels if cowbirds do not show a commensurate increase in numbers and the target of 25 pairs conforms to the recovery plan's goal of ensuring local population sizes at which the likelihood of persistence and dispersal approach asymptotic levels. Even with these guidelines, managers may need to exercise their own judgement or consult with the Technical Recovery Team or other experts, as there are additional complexities to consider. For example, a flycatcher population inhabiting a habitat patch whose current and potential capacity is fewer than 25 pairs might be considered for cessation of trapping if it has reached its carrying capacity.

7) Consult previous accounts of cowbird control programs and develop guidelines, as regards trap design, placement and seasonality, that maximize the effectiveness of cowbird control under local conditions (including actions alternative to, or in addition to, trapping).

Managers need to keep in mind that the goal of cowbird control is to aid impacted host populations, not to maximize the number of cowbirds killed. In fact, benefits to the host population with the minimum number of cowbirds killed should be the goal. 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 of large numbers of migratory cowbirds. Trapping from 1 May to 31 July should provide maximal protection for southwestern willow flycatchers. These dates would initiate trapping two weeks prior to host arrival times, as with guidelines for black-capped vireos (U. S. Fish and Wildlife Service 1991). Whether trapping is best conducted in the breeding habitat of the host, at cowbird feeding sites or both, probably depends on the local landscape. In many landscapes however, trapping in host breeding habitat is likely to be the best strategy as this removes the cowbirds that are putting hosts at risk. In addition to trapping, managers should determine whether significantly increased benefits could be gained by supplementary activities such as shooting cowbirds and removing or addling their eggs from parasitized nests. Because no single control protocol is best for all situations, managers should consult a range of published, peer-reviewed accounts of cowbird control programs (Eckrich et al. 1999, Whitfield et al. 1999, 2000; Winter and McKelvey 1999, DeCapita 2000, Griffith and Griffith 2000) for information on the design, number, placement, and visit schedule for traps and on euthanasia methods plus activities that may supplement trapping.

8) Minimize impacts on non-target species.

Measures must be taken to minimize impacts on non-target species by following appropriate trapping protocols (see references cited under Recommendation 7), e.g., by adjusting the sizes of trap openings to reduce captures of other species and by daily visits so that all non-target birds that are captured are released daily. However, reasonable levels of unavoidable negative impacts on common, non-target species should not deter cowbird trapping if control is well justified. Just as sacrificing cowbirds is an undesirable but unavoidable consequence of trapping programs that benefit endangered hosts, so too should impacts on non-target species be considered undesirable but acceptable if they are an unavoidable consequence of cowbird trapping. However, if large numbers of non-target birds are captured, research should be undertaken to elucidate the impacts on the survival and reproductive success of these other species.

9) Determine whether cowbird management actions other than control, such as removal of cowbird food sources, can result in drastic reductions in cowbird numbers.

Although cowbird control is likely to be the best management tool in most situations in which there are unacceptably high rates of parasitism (as defined under Recommendation 2), managers should determine whether their situation is best dealt with via other approaches. They should determine whether changing certain landscape conditions might allow for rapid and drastic reductions in cowbird numbers by alterations to one or a few key anthropogenic food sources. This may be especially appropriate in remote regions with little human influence. In addition, if a willow flycatcher population is very small or is in a remote area where trapping would be difficult, managers should consider whether it is preferable to shoot cowbirds and/or remove or addle cowbird eggs in parasitized nests.

10) If cowbird control is undertaken, identify and pursue long-term landscape objectives that can reduce cowbird numbers over large areas.

Even if cowbird control is undertaken, a long-term management objective should be a reduction of anthropogenic influences that provide foraging opportunities for cowbirds so as to reduce cowbird numbers at landscape levels. These influences include bird feeders and other anthropogenic food sources such as livestock. But there should be no standard distance over which livestock must be excluded from flycatcher populations because the effectiveness of livestock exclusion depends on the availability of other food sources for cowbirds in the local landscape, as described above. Indeed, in some landscapes there are so many potential food sources for cowbirds that the only limits on livestock should be exclusion from riparian habitat to protect the habitat itself. For habitat benefits that can be gained by removing livestock from riparian zones see Krueper (1993). Furthermore, livestock grazing, even in uplands, in landscapes containing flycatchers should be at levels that avoid overgrazing, as discussed in Appendix G (grazing management).

11) If cowbird control is undertaken, identify and pursue habitat enhancement actions that reduce levels of cowbird parasitism.

Even if cowbird control is undertaken, a long-term management objective should be reducing parasitism rates by measures that increase vegetation density or alter vegetation in other ways likely to reduce parasitism. Increases in the size and width of riparian habitat patches may also reduce parasitism levels.

12) Initiate programs of public education to inform people about measures that can reduce cowbird numbers and about the justification for controlling cowbirds.

Managers should inform the public that certain activities enhance cowbird abundance. Individuals should be encouraged to suspend bird feeding activities or use bird feeds that are not preferred by cowbirds (such as sunflower seeds as opposed to millet) during the passerine breeding season. Operators of feedlots, pack stations and similar facilities housing livestock should be encouraged to maintain clean conditions that minimize the amount of livestock feed (such as hay and grain) and manure that is available to foraging birds. Certain types of feed may be relatively unattractive to cowbirds. For example, cowbirds appear to show reduced interest in cubed or pelleted hay. If cowbird control is undertaken and people complain that it is wrong to kill one native bird to help another, managers should explain that cowbird 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 judgement as to the worth of one species over another but instead reflects the need the need to maintain current levels of biodiversity.

N. Literature Cited

Please see Recovery Section VI.

APPENDIX: The Importance of Nest Predation and Potential Management Actions

If cowbird control is indicated by available data, managers should keep in mind that low rates of reproductive success are the basic problem and that factors besides cowbird parasitism, in particular nest predation, may need to be addressed. Predation has a greater effect on nest success than parasitism in many situations, depending on host species and habitat type (Best and Stauffer 1980, Schmidt and Whelan 1999, Woodworth 1999, Grzybowski and Pease 2000). Sedgwick and Iko (1999) determined that nest predation reduced the lifetime reproductive output of willow flycatchers of the race *E. t. adastus*, by 0.70 fledglings per female whereas the overall 23% parasitism rate in their long term study resulted in a reduction of 0.37 fledglings. Some populations of forest nesting host species, especially those in small to moderate sized midwestern forest patches, experience such high rates of nest predation that even complete elimination of parasitism might not be sufficient to make these populations self-sustaining (Rothstein and Robinson 1994, Donovan et al. 1995, 1997; Robinson et al. 1995a,b).
As with all open-cup nesting passerines (Martin 1993, Grzybowski and Pease 2000), nest predation reduces southwestern willow flycatcher breeding success to a significant degree. Paradzick et al. (1999) found that kingsnakes (*Lampropeltis getulus*) victimized two of four flycatcher nests and three of five nests of other riparian passerines that were monitored with video cameras in Arizona. A spotted skunk (*Spilogale gracilis*) depredated one nest of another species. In a long-term study of the South Fork Kern River population of southwestern willow flycatchers in California (Whitfield et al. 1999), predation has been responsible for the loss each year of an average of 40% of all nests, (range 28-57% for five years), even with cowbird trapping. Similarly, predation caused the failure of 37% of 110 nests in 1997-98 in the New Mexico flycatcher population in the Cliff-Gila Valley (Stoleson and Finch 1999). Although these predation rates are not especially high for passerines (Grzybowski and Pease 2000), they are a major burden for an endangered species.

There may be some means of reducing nest predation. For example, chemical repellants might deter nest predators that rely on olfaction, such as snakes and mammals. Cones or collars of smooth plastic or sheet metal or sticky tape (duct tape with the adhesive side facing outwards) placed on the trunks of nest-trees and adjacent tress may sometimes keep snakes and small mammals from reaching nests. Barriers of smooth plastic or sheet metal placed on the ground around trees may keep snakes and small mammals from accessing tree trunks. It may also be possible to make habitat patches less attractive to predators. Although such measures are unlikely to reduce predation by amounts comparable to the reduction in parasitism achieved by cowbird trapping, more research is needed. Furthermore, the uncertain extent to which nest predation can be reduced should not deter managers and researchers from attempts to address losses due to predation. We will never have effective means of dealing with nest predation if managers make no attempts to lessen it, which has been the case so far in all recovery efforts for endangered cowbird hosts. If actions are taken to deter predation, nests will have to be monitored and this means that cowbird eggs can be removed or addled at nests that are accessible, thereby also providing protection against some or most of the costs of parasitism.

Given the lack of highly effective means of predator deterrence and the relative ease with which cowbird parasitism can be reduced, it is unlikely that there will be situations in which this approach should be done instead of cowbird control but managers might give predator deterrence and cowbird control high priority in certain circumstances. Such circumstances might be habitat patches that are just beginning to be colonized or populations that occupy vital spatial positions as defined by population viability analysis. As we have done for southwestern willow flycatchers, recovery efforts for black-capped vireos and golden-cheeked warblers also noted the importance of predation and amelioration of this pressure as a potential management action (U. S. Fish and Wildlife Service 1991, 1992).

If attempts are made to lessen nest predation, managers should focus attention deterring predation of flycatcher nests not on complete predator control or removal, as the latter actions could have ramifications throughout an ecosystem. Any attempts to remove or kill off predators should be done only after in depth consideration of the sorts of issues raised in our list of the downsides of cowbird control, such as ethical considerations and the need for sustained year to year intervention. A similar cautionary note about predator control has been proposed for black-capped vireo recovery efforts (U. S. Fish and Wildlife Service 1991). However, it might be worthwhile to remove individual predators that appear to specialize on flycatcher nests. We note that as with cowbird removal, predator removal consistently boosts avian reproductive output but often does not increase the numbers of breeding birds (Cote and Sutherland 1997).