FGC - 670.1 (3/94)

A PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION

For action pursuant to Section 670.1, Title 14, California Code of Regulations (CCR) and Sections 2072 and 2073 of the Fish and Game Code relating to listing and delisting endangered and threatened species of plants and animals.

I. SPECIES BEING PETITIONED:

Common Name: Tricolored blackbird

Scientific Name: (Agelaius tricolor)

II. RECOMMENDED ACTION:

(Check appropriate categories)

a. List ■

As Endangered ■

As Threatened ☐

b. Change Status ☐

from __________

to __________

Or Delist ☐

III. AUTHOR OF PETITION:

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I hereby certify that, to the best of my knowledge, all statements made in this petition are true and complete.

Signature: Lisa T. Belenky

Date: August 19, 2015

BEFORE THE CALIFORNIA FISH AND GAME COMMISSION

A Petition to List the Tricolored Blackbird (*Agelaius tricolor*) as Endangered under the California Endangered Species Act and Request for Emergency Action to Protect the Species

tricolor blackbird, Agelaius tricolor, Dave Menke, USFWS

Notice of Petition

For action pursuant to Section 670.1, Title 14, California Code of Regulations (CCR) and Sections 2072 and 2073 of the Fish and Game Code relating to listing and delisting endangered and threatened species of plants and animals.

I. SPECIES BEING PETITIONED:

Common Name: Tricolored Blackbird (*Agelaius tricolor*)

II. RECOMMENDED ACTION: Immediate Listing as Endangered with Emergency Regulations

The Center for Biological Diversity submits this petition to list the Tricolored Blackbird (*Agelaius tricolor*) as endangered throughout its range in California, under the California Endangered Species Act (California Fish and Game Code §§ 2050 et seq., "CESA"). This petition demonstrates that the Tricolored Blackbird clearly warrants listing under CESA based on the factors specified in the statute.

This petition provides identical information as contained in the Center's 2014 petition with the addition of an addendum providing new research.

III. AUTHORS OF PETITION:

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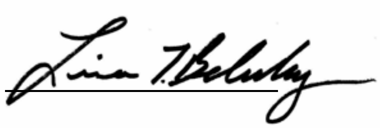
I hereby certify that, to the best of my knowledge, all statements made in this petition are true and complete.

Signature:  Date: August 19, 2015

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Executive Summary

The Tricolored Blackbird ("Tricolor;" *Agelaius tricolor*) is a colonial-nesting passerine largely endemic to California. It forms the largest colonies of any passerine in North America since the extinction of the Passenger Pigeon (*Ectopistes migratorius*, Bent 1958). Colonially nesting birds are particularly vulnerable to extinction because a small number of colonies can include a large proportion of the population; thus human activities can have catastrophic effects by killing adults or chicks or destroying habitat (Cook and Toft 2005). Such was the fate of the colonial Passenger Pigeon, Carolina Parakeet (*Conuropsis carolinensis*), and Great Auk (*Pinguinus impennis*) and will be the fate of the Tricolored Blackbird if immediate action is not taken. As scientists working with the Tricolored Blackbird noted, early actions are needed to protect colonial bird species from rapid collapse.

> **"Surely the legacy of Passenger Pigeon should be our understanding of how such extinctions can occur rapidly in extremely abundant organisms because of non-linear population dynamics and thresholds caused by inverse density dependence. Failure to address the impact of habitat and human activities on reproductive success of Tricolored Blackbird may again lead to the extinction of a once-abundant bird**." (Cook and Toft 2005:86.)

Tricolored blackbird populations are declining at an alarming rate in large part due to the direct loss and degradation of habitat from human activities. This includes historical market hunting of blackbirds, poisonings and shootings to protect crops from blackbirds, pesticide use, and harvest of grain crops grown for dairy silage and other agricultural grain crops and routine plowing of weedy fields throughout most of its range during nesting season. For example, every year, thousands of Tricolors, often entire colonies of tens of thousands of birds representing the largest known colonies in a given year, nest unsuccessfully on agricultural lands because their eggs and nests are destroyed during harvest or weed abatement activities (Beedy and Hamilton 1999, Hamilton 2004, Cook and Toft 2005, Meese 2006, 2007, 2008, 2009a, 2011). The concentration of most of the known Tricolor population in a few large breeding colonies increases the risk of major reproductive failures, especially in vulnerable habitats such as active agricultural fields (Cook and Toft 2005, Meese 2013). Moreover, entire colonies are often predated by rats, egrets, herons, coyotes, and other species, some colonies are partially or completely destroyed by storms, and insufficient insect prey in foraging areas near to nesting substrates appears to be causing widespread reproductive failure even in colonies unperturbed by harvest, predation, or storms (Meese 2006, 2007, 2008, 2009a, 2011, 2013). Because these factors are contributing annually to significant breeding failure, efforts to reduce and reverse population decline are critically needed. Unfortunately, voluntary measures undertaken over the past decade have not stopped the decline of the species or destruction of nesting habitat. Therefore, in order to ensure survival of the species the California Fish and Game Commission ("the Commission") should immediately list the Tricolored Blackbird as endangered and adopt emergency regulations to protect its nesting habitat.

The geographic range of Tricolors is generally restricted to California's Central Valley and surrounding foothills, and sparsely throughout coastal and inland locations north of the Central Valley and in southern California (Beedy and Hamilton 1999). California supports more than 99% of the population, but the species has also been reported in small numbers in southern

Oregon and northernmost western coastal Baja California with a single colony of 60 birds in western Nevada, and a similar number in central Washington (Beedy and Hamilton 1997, 1999, DeHaven 2000). The Tricolor's basic requirements for selecting breeding sites are open accessible water, a protected nesting substrate such as flooded or thorny or spiny vegetation, and adequate insect prey within a few kilometers of the nesting colony (Beedy and Hamilton 1999, Shuford and Gardali 2008). Historically, rivers flowing into the Central Valley would flood and create extensive marshes, providing abundant high-quality breeding habitat for Tricolors and other wetland-dependent species, but much of this habitat has been obliterated. Tricolors have demonstrated some flexibility in shifting breeding from marshes to other spiny and thorny vegetation types such as non-native Himalayan blackberry and thistles as well as newly developed silage crops such as Triticale. However, none of these new nesting habitat types are given any regulatory protection, rendering entire colonies vulnerable to complete reproductive failure during the active nesting season due to agricultural activities. In addition, Tricolor colonies often switch nesting locations from year to year, substantially complicating conservation efforts.

The Tricolor is sympatric with and morphologically similar to the Red-winged Blackbird ("Red-wing;" *A. phoeniceus*). However, unlike Red-wings, Tricolors breed in dense colonies, often traveling long distances to forage for their chicks, and males defend relatively smaller territories within their colonies, mating with one to several females per year (Beedy and Hamilton 1999). The overall distribution and location of nesting sites vary from year to year, and Tricolors are itinerant breeders, i.e., they may nest more than once at different locations during the breeding season (Hamilton 1998).

Tricolors form the largest breeding colonies of any North American landbird, and breeding colonies recently consisted of tens of thousands of birds at a single site. While Tricolor colonies can consist of thousands of breeding birds, thus giving an appearance of high local abundance to casual observers, the status of the bird is of great concern because the overall population has declined dramatically over the past 70 years, a decline that appears to have accelerated in the past 6 years (Meese 2014), its geographical range is largely restricted to California, and its gregarious nesting behavior renders colonies vulnerable to large-scale nesting failures due to destruction of active nests in its agricultural habitats and high levels of predation in its little remaining native emergent marsh habitat, predominately cattails and bulrushes. Every year, Tricolors experience large losses of reproductive effort to crop-harvesting and other agricultural activities, and predation, and suffer habitat losses to land conversions from rangeland to vineyards, orchards, and urban development and an unknown number are killed in autumn in rice paddies in the Sacramento Valley . Despite awareness of widespread reproductive losses over the past two decades, FWS, the Commission, and DFW have failed to take any serious regulatory action. The Center for Biological Diversity submitted a petition to list the Tricolor as an endangered species under the California and Federal Endangered Species Acts in 2004 due to the documented population decline from historical number and the serious threats from agricultural harvest and habitat loss, but the petition was denied and the threats continued. Consequently, the population of Tricolors continued to drop precipitously to the point where the need for emergency action is now unequivocal.

The Tricolored Blackbird was once considered one of the most abundant bird species throughout much of its range (Cook and Toft 2005). In 1859, Heermann wrote that wintering flocks of Tricolors would “darken the sky for some distance by their masses,” a description similar to that of the now-extinct Passenger Pigeon (Cook and Toft 2005). Beginning in the 1930s and continuing until 2014, numerous efforts have been made to estimate abundance of Tricolors (Neff 1937, DeHaven et al. 1975, Hamilton et al. 1995, Beedy and Hamilton 1997, Hamilton 2000, Kelsey 2008, Kyle and Kelsey 2011, Meese 2014). Numbers of Tricolors estimated in the 1930s compared with numbers estimated in 2014 very clearly and unequivocally demonstrate an extremely precipitous decline in the population of Tricolors in the Central Valley, the historical stronghold of the species, and elsewhere including the Central Coast and southern California. Population trends of Tricolors in the Central Valley indicated a decline of at least 50% between the 1930s and early 1970s (DeHaven et al. 1975), and an additional decline of approximately 56% of the remaining population was reported from 1994 to 2000 (Hamilton 2000). More recent statewide surveys included greatly expanded efforts with more sites, and these surveys documented additional dramatic declines: from an initial survey count of 395,000 birds in 2008, numbers declined dramatically to a count of about 145,000 in 2014—despite the fact that this was the largest effort ever expended to census the entire population of Tricolored Blackbirds, this was the smallest population ever recorded. The situation is dire indeed.

Petitioner requests immediate protection of the Tricolored Blackbird. The Center is extremely concerned about the continued destruction of Tricolor nests on dairy farms and other agricultural lands in the Central Valley and the failure of voluntary measures to stem the decline in abundance. The Center is also concerned with the failure of the wildlife agencies to adequately protect active nests and birds in this critical Tricolor nesting habitat—which currently supports some of the biggest colonies of Tricolors comprising a large proportion of the remaining population. Other important nesting substrates, such as Himalayan blackberry, are occasionally destroyed by herbicide application (Meese 2011). Widespread reproductive failures are regularly documented even in the species’ native marsh habitat, due to predation and lack of insects with which to feed young (Meese 2013). As a result, through this letter, the Center is requesting immediate action by the California Fish and Game Commission prohibiting (or at a minimum delaying) harvesting and plowing activities on private lands used for Tricolor breeding during the upcoming 2015 nesting season. These activities are already in clear violation of the California Fish and Game Code section 3503 which protects all birds’ nests and eggs from destruction (Cal. Fish & G. Code § 3503 [“It is unlawful to “take, possess, or needlessly destroy the nest or eggs of any bird”]). Furthermore, these activities are in large part responsible for current precipitous decline of the species that necessitates immediate listing under the California Endangered Species Acts as discussed in detail below.

Petitioner acknowledges that the California Department of Fish and Wildlife (“CDFW”) and other partners have been engaging in “public/private cooperation” to address the ongoing violations of the applicable statutes and the resultant large-scale nesting failures. Thanks to these voluntary measures, many thousands of nests have been saved from destruction during crop harvest. However, while laudable, these measures are only acceptable mitigation if they are consistently negotiated and proven effective at significantly reducing Tricolor nest failures. Given the past efforts, it is unsurprising that CDFW takes the position that crop purchases or reimbursements for delayed harvest are not a feasible long-term solution for Tricolor habitat management on private agricultural lands. Petitioner agrees that such voluntary and cooperative methods will not be sufficient to slow or reverse the Tricolor's recent precipitous decline. For example, in 2011 (the last year for which detailed data were available on colony fates) 56% of all nests in silage fields were destroyed despite efforts to contact farmers and coordinate buy-outs of harvest delays (Meese 2011). Numerous voluntary recommendations to halt the population declines have been proposed in the reports on the 2008, 2011, and 2014 statewide surveys, but these recommendations have not been widely adopted and as a result the populations continue to plummet. The Tricolored Blackbird Working Group set a recovery goal of 725,000 Tricolored Blackbirds in 2007 but every year since then the population has declined, so it has rapidly become much more difficult to meet the recovery goal. Because CDFW cannot demonstrate that concrete measures will be implemented immediately to protect critical nesting sites on private lands in the 2015 breeding season under the voluntary and cooperative partnerships, listing is necessary and establishment of regulatory protective measures to reduce known sources of Tricolored Blackbird mortality.

Even with some voluntary public/private cooperation in place for this nesting season, the Tricolor indisputably warrants listing under the California Endangered Species Acts as discussed more fully below. As a result, pursuant to the California Endangered Species Act, California Fish & Game Code §§ 2070, *et seq*., the Center for Biological Diversity hereby formally petitions the California Fish and Game Commission to list the Tricolored Blackbird as "endangered" under the California Endangered Species Act. In addition, the Center hereby requests that the Commission immediately adopt emergency regulations to list the Tricolored Blackbird as endangered under California Fish and Game Code Section 2076.5.

Procedural History

As the Commission is aware, the Center for Biological Diversity petitioned for an emergency listing of the Tricolored Blackbird in 2004 under both the California Endangered Species Act ("CESA") and the Federal Endangered Species Act ("ESA") based on the then-already precarious status of the species due to declining populations. The petition was denied by both the Commission and the U.S. Fish and Wildlife Service (*see* Federal Register 2006). Currently the Tricolor is a nongame species of management concern and California Species of Special Concern, the Bureau of Land Management listed it as a sensitive species, and it has been on the IUCN red list of endangered species since 2006 (IUCN 2011), but given precipitous population declines even since 2004, clearly the Tricolor requires the safety net of the California Endangered Species Act.

While the Tricolored Blackbird is considered a non-game bird of management concern by FWS, this designation does not provide any specific legal protection to the species. Furthermore, while the species is theoretically afforded protection under the federal Migratory Bird Treaty Act (MBTA), the statute is rarely if ever enforced against private parties.

The Tricolor is also designated a species of special concern by CDFW and theoretically must be considered during project actions subject to the California Environmental Quality Act

("CEQA"). However, this status does not protect the species from activities that do not trigger CEQA's environmental review requirements, and even when considered, CEQA's substantive mandates for environmental protection have not been implemented with regards to protection of the Tricolor. The California Fish and Game Code section 3503 protects all active nests and eggs from destruction or "take", however this statutory prohibition has not been consistently if ever enforced by CDFW to protect the Tricolor from impacts on agricultural fields during the nesting season.

The CESA Listing Process and Standard for Acceptance of a Petition

Recognizing that certain species of plants and animals have become extinct "as a consequence of man's activities, untempered by adequate concern for conservation," (Fish & G. Code § 2051 (a)), that other species are in danger of extinction, and that "[t]hese species of fish, wildlife, and plants are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of this state, and the conservation, protection, and enhancement of these species and their habitat is of statewide concern" (Fish & G. Code § 2051 (c)), the California Legislature enacted the California Endangered Species Act.

The purpose of CESA is to "conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat...." Fish & G. Code § 2052. To this end, CESA provides for the listing of species as "threatened"[1] and "endangered."[2] The Commission is the administrative body that makes all final decisions as to which species shall be listed under CESA, while the CDFW is the expert agency that makes recommendations as to which species warrant listing.

The listing process may be set in motion in two ways: "any person" may petition the Commission to list a species, or the CDFW may on its own initiative put forward a species for consideration. Fish & G. Code § 2072.7. In the case of a citizen proposal, CESA sets forth a process for listing that contains several discrete steps. Upon receipt of a petition to list a species, a 90-day review period ensues during which the Commission refers the petition to CDFW, as the relevant expert agency, to prepare a detailed report. The CDFW's report must determine whether the petition, along with other relevant information possessed or received by the Department, contains sufficient information indicating that listing may be warranted. Fish & G. Code § 2073.5.
During this period interested persons are notified of the petition and public comments are accepted by the Commission. Fish & G. Code § 2073.3. After receipt of CDFW's report, the Commission considers the petition at a public hearing. Fish & G. Code § 2074. At this time the

[1] "Threatened species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by this chapter. Fish & G. Code § 2067.
[2] "Endangered species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease." Fish & G. Code § 2062.

Commission is charged with its first substantive decision: determining whether the petition, together with CDFW's written report, and comments and testimony received, present sufficient information to indicate that listing of the species "may be warranted." Fish & G. Code § 2074.2. This standard has been interpreted by courts as the amount of information sufficient to "lead a reasonable person to conclude there is a substantial possibility the requested listing could occur." *Natural Resources Defense Council v. California Fish and Game Comm*. 28 Cal.App.4th at 1125, 1129. If the petition, together with CDFW's report and comments received, indicates that listing "may be warranted," then the Commission must accept the petition and designate the species as a "candidate species." Fish & G. Code § 2074.2.

Once the petition is accepted by the Commission, then a more exacting level of review commences. CDFW has twelve months from the date of the petition's acceptance to complete a full status review of the species, seek peer review of the draft report, make the final report available to the public for at least 30 days, and recommend whether such listing "is warranted;" CDFW may seek an extension of up to six months if needed to complete peer review and public review. Fish & Game Code § 2074.6. Following receipt of CDFW's status review, the Commission holds an additional public hearing, which may be continued, and determines whether listing of the species "is warranted." Fish & Game Code §2075.5. If the Commission finds that the species is faced with extinction throughout all or a significant portion of its range, it must list the species as endangered. Fish & G. Code § 2062. If the Commission finds that the species is likely to become an endangered species in the foreseeable future, it must list the species as threatened. Fish & G. Code § 2067.

Notwithstanding these listing procedures, the Commission may adopt a regulation that adds a species to the list of threatened or endangered species at any time if the Commission finds that there is any emergency posing a significant threat to the continued existence of the species. Fish & G. Code § 2076.5. Petitioner asks that the Commission do so here.

1.0 Population Status and Trend

> **If a flock of goldfinches is called a "charm," and a flock of crows, a "murder," what is a flock of Tricolored Blackbirds (*Agelaius tricolor*) called? Whatever the word, it could not possibly be adequate to describe the mind-boggling energy and excitement generated by a flock of over 50,000 Tricolors settling at a colony. Whether an avid birder or weekend naturalist, you can't help but be amazed by this sight, for it is one of the Central Valley's most spectacular natural phenomena. (**Edson and Green, Central Valley Bird Club Bulletin 2004:Volume 7.)

Tricolored Blackbirds form the largest breeding colonies of any North American landbird, a distinction once held by the now-extinct Passenger Pigeon. In the 1800s and early 1900s, the Tricolored Blackbird was considered one of the most abundant bird species throughout much of its range, which consists of low-elevation wetlands and grasslands of Central, Coastal, and Southern California (Cook and Toft 2005). In 1859, Heermann wrote that wintering flocks of Tricolors would "darken the sky for some distance by their masses," a description notably similar to that of the Passenger Pigeon (Cook and Toft 2005). However, a history of market hunting and massive loss of native marshland habitat drastically reduced the population by the mid-twentieth century. The majority of the population, with the last statewide survey counting fewer than150,000 birds, can still breed in colonies of tens of thousands, but there remain few such large nesting colonies, and those that remain are extremely vulnerable to human activities such as crop harvesting while nests are still active and loss or degradation of suitable foraging habitats (Cook and Toft 2005). This species is on a clear trajectory towards extinction.

Much information is readily and publicly available regarding historical and current population status and trend of the Tricolored Blackbird. The best source of information is from the excellent Tricolored Blackbird Portal that is maintained by the University of California, Davis and available at: tricolor.ice.ucdavis.edu. The Portal provides on-line data entry to hundreds of users and provides access to field data, reports, and published articles about the Tricolored Blackbird. The Portal provides a history of research on population status and trend of the Tricolored Blackbird, which is paraphrased below.

Although the Tricolored Blackbird is mentioned in several articles and books dating to the mid-20th century, the first field work that was focused on Tricolors was conducted by Johnson Neff, a biologist who worked for the Bureau of Biological Survey, the forerunner of today's U.S. Fish & Wildlife Service. Neff's work was primarily focused on the Sacramento Valley, but he also worked at sites in the San Joaquin Valley and in southern California in conjunction with other state and federal biologists and volunteers. After widespread reports of the birds' disappearance from coastal locations, Neff conducted six years of field surveys (from 1931–1936), and additional banding of nestlings until 1940, to determine the status of the birds in the Central Valley.

After 1940, perhaps in response to Neff's finding of fairly large numbers of remaining birds (e.g., over 736,000 adults in eight counties and 282,000 nests at one site in Glenn County in 1934), there followed a more than 20-year period of relatively little research into Tricolor status and biology. Then, during the 1970s, Richard DeHaven of FWS conducted surveys for Tricolors in first the Central Valley and then the entire breeding range (excluding Baja California). These efforts were undertaken to determine changes in the population status of the Tricolor since the last surveys in the 1940s.

In the 1980s Edward (Ted) Beedy began field investigations of Tricolors with an emphasis on estimating the abundance of the species and determining factors responsible for the observed nesting failures of colonies in the Central Valley. Shortly thereafter, William (Bill) Hamilton of U. C. Davis began his field investigations. Hamilton's work extended for 13 field seasons, through 2005, and covered a wide range of topics, including population estimation, productivity estimation, foraging ecology, and the phenomenon known as "itinerant breeding," whereby individuals breed once in one location and then fly northward to a different location to breed again. Beedy and Hamilton wrote the *Birds of North America* treatment of the Tricolored Blackbird (Beedy and Hamilton 1999).

Beedy and Hamilton suggested using volunteers to conduct a statewide survey during a 3-day interval in April to best estimate the global population of the species. Early attempts at statewide surveys to assess population status and trend were conducted in 1994, 1997, 2000, 2001, and

2005. Of these, surveys conducted in 1994, 1997, and 2000 were similar enough in scope and effort to enable the detection of a significant downward trend in the population during this period (Cook and Toft 2005).

Beginning in 2008, the triennial statewide survey was revamped to include a strict new hierarchical coordination structure to standardize methodology and ensure more equal survey effort and thus more comparable results. The Statewide Survey, which occurs in mid-to-late April, is a volunteer effort with participants from most lower-elevation regions of California within the range of the Tricolor, and directed by a statewide coordinator. The 2008 survey was the first to use county coordinators—local experts with extensive experience with Tricolors on the local level—and this new hierarchical protocol (statewide coordinator, county coordinators, local participants) was used in the 2008, 2011, and 2014 surveys. The survey protocol is designed to document both presence and absence at a site, along with an estimate of the number of Tricolors and characteristics of occupied sites (nesting substrate, distance to water, presence of stored grains). These three most recent statewide surveys provide current, relatively more reliable information on the numbers and distribution of Tricolored Blackbirds throughout California and are a means to document trends in the population. These surveys also complement more intensive field efforts that provide insights into the factors causing the observed population decline.

Below this petition describes both the historical and more recent survey methodology and results.

1.1 Historical Population Estimates

The first surveys and population estimates for Tricolors were instigated by Neff in the early 1930s. During the 1960s, other researchers focused their studies on ecology and behavior of the species (e.g., Orians 1960, 1961a, 1961b,Orians and Collier 1962, Payne 1969), but did not provide range-wide population estimates. DeHaven et al. (1975) conducted a second set of more comprehensive range-wide surveys to determine changes in the population status of Tricolors since Neff's work in the 1930s.

From 1930 to 1936, Neff (1937) estimated the population of Tricolors using several methods. The author and cooperators checked the active population of colonies numerous times by conducting flight-line counts (i.e., counting the birds flying in or out across a base line for five minutes); checking distance from base line to feeding ground or nesting site, and estimating probable time required for each trip. Nests were counted by walking nest transects: detailed observations in a randomly-chosen subset of a colony that counted all nests within a 6-foot wide strip and extrapolating from this sample to estimate the total number of nests. Generally, the number of nests rather than the number of breeding adults was reported.

Based on number of nests reported and multiplying by 1.5 (mean estimated sex ratio of 2 females breeding with each male), Beedy and Hamilton (1997) calculated that the surveyors in the 1930s observed as many as 736,500 adults per year in just 8 counties. Neff (1937) documented numerous large colonies, including one in 1934 in Glenn County that contained about 200,000 nests (300,000 breeding adults), over an area greater than 24 ha. Several other colonies in

Sacramento and Butte Counties contained more than 100,000 nests. Hamilton et al. (1995) calculated that Neff observed about 1,105,100 individual Tricolors. Neff, however, concentrated most of his effort in the Sacramento Valley so most likely underestimated total population size at the time.

In 1969 and 1970, DeHaven et al. (1975) surveyed the Central Valley Tricolor breeding range by car, and in 1971, the entire breeding range (excluding Baja California) was surveyed. In 1972, the authors surveyed from the northern San Joaquin Valley to southern Oregon. Additional information was provided to the authors by volunteer ornithologists. Population estimates were made by counts and by projections based on research findings that each Tricolor female attends one active nest and that males mate with on average two females.

DeHaven et al. (1975) estimated the number of breeding birds at 157 colonies. Of these, 40 colonies (25%) had fewer than 1,000 birds, 97 colonies (62%) had from 1,000 to 10,000 birds, and 20 colonies (13%) had more than 10,000 birds. All colonies outside the Central Valley contained fewer than 10,000 Tricolors. They found fewer colonies, fewer non-breeding Tricolors, no nesting areas even approaching the size of some of the previously reported colonies, fewer birds in the largest colonies, and fewer total Tricolors than Neff (1937). Overall, DeHaven et al. (1975) concluded that the population of Tricolors has likely been reduced by more than 50% below levels reported in the 1930s, and that downward trajectory was continuing.

Beedy et al. (1991) summarized all historical and recent breeding accounts, including unpublished observer reports from a variety of sources. Based upon this information they concluded that the Tricolor had declined further from population estimates by DeHaven et al (1975), and that this decline was coincident with continuing losses of wetland habitats in the Central Valley. They reported a range of about 35,000–110,000 breeding adults per year in the 1980s, with an approximate average of 52,000 breeding adults reported per year in that decade (from Beedy and Hamilton 1997). Unfortunately their population estimates were not based well enough on field surveys and so cannot be considered adequate for evaluating the population for the period addressed. For example, Beedy et al. (1991) estimated a 76% decline in colony size between the 1930s and 1970s, whereas Graves et al. (2013), using a more comprehensive database, documented a 63% decline in mean colony size specifically from 1935 to 1975. Further, Beedy et al. (1991) documented a 62% decline in average colony size from the 1970s to the 1980s and Cook and Toft (2005) demonstrated a decline in average colony size from 1994 to 2000. Although Graves et al. (2013) found no decline from the 1970s to 2009, that study appears to have combined data that were not truly comparable. Since 2009, there has been a well documented marked decline in average colony sizes (Meese 2014), discussed below.

Three even more comprehensive surveys were conducted in 1994, 1997, and 2000 (Hamilton et al. 1995, Beedy and Hamilton 1997, Hamilton 2000). These surveys were co-sponsored by FWS and CDFW to document the Tricolor's population status, including investigating size and location of colonies, nesting habitat characteristics, behavior, reproductive success as correlated with habitat type, patterns of land ownership, and total population size and distribution. The surveys were coordinated by experienced Tricolor researchers at U.C. Davis and included these researchers in addition to numerous local volunteer ornithologists and agency personnel as participants. U.C. Davis researchers often provided follow-up confirmation of the larger volunteer-reported colonies.

The total number of Tricolors counted during the 1994 statewide survey was estimated to be 369,359 individuals. This suggests a decrease in population abundance of at least 50% (and probably more) based on Neff's (1937) results between the 1930s and early 1990s and a clear downward trend in the population. The ten largest colonies located during the survey and additional full season range-wide surveys in 1994 included 60.5% of all breeding individuals, pointing to the importance of protecting large breeding colonies and their nesting and foraging habitat, if the species is to be conserved. Importantly, full season survey results indicated that 70% of all Tricolor nests and 86% of all foraging by nesting birds occurred on private agricultural land in 1994 (Hamilton et al. 1995). Approximately 54% of all observed Tricolor nesting efforts were associated with agricultural crops, primarily grain crops grown for silage at dairies (Beedy and Hamilton 1997).

The total number of Tricolors counted during the 1997 survey was estimated to be 232, 960 individuals. This suggests a decrease in the population by approximately 37% between 1994 and 1997. Population declines were most apparent in the species' historical stronghold in the Central Valley, including Sacramento, Fresno, Kern, and Merced Counties. Approximately 75% of all breeding adults located during the survey were concentrated within the 10 largest colonies.

The total number of Tricolors located during the 2000 survey was estimated to be 162,508 individuals. This suggests an additional decrease in the population by approximately 30% between 1997 and 2000 and an overall decline of approximately 56% between 1994 and 2000. Fewer colonies were located in 2000 than in 1994 (Hamilton 2000) and colonies were smaller on average in 2000 compared to 1994 (Cook and Toft 2005). These data likely underestimate the true magnitude of change that occurred during this time period. The reliability of the censuses to estimate the Tricolor population likely increased over time because the number of participants grew and participants were better informed about colony locations in each succeeding year Hamilton (2000) states "…the method of the Census and the survey, to reinvestigate all known breeding places and to search for new ones, has become an increasingly complete assessment of Tricolored Blackbird distribution and abundance. The 2000 Census probably located a greater proportion of the entire population that did censuses in previous years."

More than 40% of all Tricolor reproductive effort in 2000 was associated with dairies in the San Joaquin Valley and southern California (Hamilton 2000). Hamilton (2000) pointed out that conditions were more favorable for breeding Tricolors in 2000 than 1999, including the buy-out of the Tevelde and George Colonies in Tulare County and the success of the Delevan NWR and Hills Duck Club (Colusa County) and Merced NWF (Merced County) colonies. However, at least four large colonies, one in Fresno County, two in Kings County, and one in Tulare County, were lost to crop harvest in 2000.

Despite the favorable conditions in 2000, Hamilton (2000) stated that "...the central conclusion of the census and survey is that tricolors are continuing to decline precipitously in numbers … The conclusion that tricolor numbers are plummeting is based not only upon these data, but also on the collective experience of local experts throughout California who have observed tricolors over long intervals." One of the participants in the 2000 survey was DeHaven, who surveyed the same area in the 1970s, and who wrote in a FWS white paper "[e]vidence of habitat loss, from urban expansion and agricultural conversions from such high-value (for Tricolors) uses as livestock forage production, to low- or no-value uses such as vineyards and orchards, was widespread." He further noted "[t]hese present observations support a conclusion of another large population decline between the 1970s and today."

In 2001, Point Reyes Bird Observatory (PRBO) coordinated the Tricolored Blackbird survey in California. The PRBO effort did not entail a robust count, but rather cited reports submitted by participants over several months (Humple and Churchwell 2002). The survey included season-long coverage instead of just 2–3 days in April to include colonies that might be completely missed if depredation or draining occurred prior to the visit date. However, this methodology is problematic because as itinerant breeders some of the birds were probably double-counted. Data were available for a total of 48 sites visited: 142, 045 breeding birds were counted and the largest colony size was approximately 30,000 (Humple and Churchwell 2002).

In sum, survey results from 1994 to 2001 show that the number of Tricolors counted plummeted from an estimated 370,000 in 1994, to 240,000 in 1997, to 162,000 in 2000, to 142,045 in 2001. Numbers are unknown from the 2005 survey. These population data suggest a decline of 62% in less than a decade. Fewer colonies were located in 2000 than in 1994 (Hamilton 2000) and colonies were smaller on average in 2000 compared to 1994 (Cook and Toft 2005). The earlier surveys were important in assessing general trends in population and colony sizes in different regions, but starting in 2008 the surveys provided even more comprehensive coverage of the state, and utilized a means for the public to input data with the advent of the Tricolored Blackbird Portal Taken together, the available data and information shows a clear and alarming downward trend of the Tricolored Blackbird population in California.

1.2 Recent Population Estimates

The 2008 statewide survey was coordinated by Audubon California (Kelsey 2008). The goal of the survey was to "develop the best statewide population estimate possible, using volunteers across the state." Audubon California placed particular emphasis on expanding overall geographic coverage and on thoroughly surveying southern California counties. The survey used a three-tiered system:

1st tier is a statewide coordinator,
2nd tier is county coordinators, and
3rd tier is volunteer participants.

This three-tiered structure allowed for increased recruitment of volunteers, improved survey coverage, and was more thoroughly based on the local knowledge embodied in the county coordinators. The 2008, 2011, and 2014 surveys all were conducted using the same three-tiered structure and same survey protocols for recruiting and training volunteers and conducting the surveys (e.g., identifying birds, estimating colony size, and recording colony attributes such as nesting substrates, distance to open water, and presence of stored grains). And significantly, the USFWS funded the development of the Tricolored Blackbird Portal prior to the 2008 survey, which enabled for the first time the on-line entry of records of observations of breeding birds.

The 2008 survey was carried out April 25 to 27. However, during this time several large colonies nesting in silage were harvested, thus complicating the count (Kelsey 2008). In response, the 2011 survey was conducted April 15 to 17, earlier than previous surveys to better avoid the harvest time of silage crops. The 2014 survey was conducted from April 18 to 20. The three-day window captures as many birds as possible on colonies during their first breeding attempt of the year while using a narrow window to ensure birds are not double-counted, as colonies and individual birds can shift locations over relatively short periods of time during the breeding season. Below are the population results.

2008—A total of 155 volunteers participated in the 2008 survey, visiting 361 historical and new sites in 38 counties within California. The census total was 394,858 birds at 180 sites. During the survey, 135 sites were documented as breeding colonies with an estimated 392,581 breeding birds. Out of 38 counties surveyed, there were 32 in which Tricolored Blackbirds were detected.

Regional distribution was similar to that reported from previous surveys, with the vast majority of birds (86.4%) occurring in the San Joaquin Valley. Nine of the top 10 and 15 of the top 20 colonies were in the San Joaquin Valley, with 63% of the population occurring at only five colony sites in Merced, Tulare, and Kern counties. In southern California, 5,487 birds were counted at 24 sites. Several known historical sites occurred on private land and volunteers were unable to gain access. As a result, this may be an underestimate of the number of birds, but Kelsey (2008) noted that there is no reason to suspect that a large number of birds were left uncounted in southern California.

2011—A total of 100 volunteers participated in the 2011 statewide survey, visiting 608 historical and new Tricolored Blackbird colony sites in 38 counties. The statewide population estimate was 259,322 birds at 138 sites in 29 counties.

The majority of Tricolored Blackbirds (89%) again were counted in the San Joaquin Valley and Tulare Basin, matching the results in prior surveys. The three largest concentrations of birds occurred in Merced (54%), Kern (24%), and Tulare (9%) counties. The top 10 largest colonies for 2011 were found in these three counties and 16 of the top 22 were from the San Joaquin Valley or Tulare Basin. Notably, 65% of the population was consolidated into only six colony sites in Merced, Kern, and Tulare counties. The southern California subpopulation was estimated to be 5,965 individuals at 32 sites in three counties, with a total of 74 sites visited.

2014—Overall, 38 county coordinators and 143 volunteers participated in the survey. A total of 145,135 birds were counted in 37 counties, out of 41 counties and 802 locations surveyed. Tricolored blackbirds were observed at a total of 143 locations. This represents a near-quadrupling of the number of locations surveyed since the 2000 statewide survey, when only 206 sites were surveyed (Hamilton 2000).

1.3 Summary

In 2014, 75 new location records were added by 27 different Portal users as result of the statewide survey. This is the same number of new location records that were added as a result of the 2011 statewide survey. In 2008, 180 sites were visited, while in 2011, 608 sites were visited and in 2014, 802 sites were visited. Despite this substantial increase in sites that were visited, the total number of birds counted declined dramatically, from 394,858 birds in 2008 to 259,322 birds in 2011 to just 145,135 birds in 2014.

Every major study of *A. tricolor* published since the 1970s has sounded the alarm bell regarding the precipitous conservation status of the species:

> "Further research is needed to determine whether this downward trend, which may have reduced the Central Valley population by more than 50%, is continuing, and whether it has yet reached the point of concern.…" (DeHaven et al. 1975)

> "Reported tricolor colony size estimates in 1994 compared to the total count in 1997...indicated that the total tricolor population declined by about 37%, and the greatest declines occurred in Sacramento, Fresno, Kern, and Merced Counties, which hosted about 72% of the total adults observed in April 1994...In some portions of their range, tricolors have definitely declined or been eliminated, including local extirpation in portions of the Central Valley where they were once abundant...and many historical sites in coastal southern California counties." (Beedy and Hamilton 1997)

> "The central conclusion of the Census and survey is that tricolors are continuing to decline precipitously in numbers, from millions in the 1930s...to an estimated 750,000 in 1975..., 370,000 as of the 1994 Census and 162,000 in this account for 2000. The conclusion that tricolor numbers are plummeting is based not only upon these data, but also on the collective experience of local experts throughout California...Tricolors are a diminished natural spectacle in the Central Valley and in Southern California, the former strongholds of this species." (Hamilton 2000)

> "The long-term population trends and patterns in reproduction reported in this study reveal that the Tricolored Blackbird possesses most of the traits that ultimately led to the extinction of the Passenger Pigeon in the same ecological circumstances. These factors include the loss of vast areas of native wetland along with the increasing loss of upland, non-native vegetation favorable for nesting, the trend of decreasing colony size in a highly social breeder, a habit of itinerant breeding, and wholesale mowing down of the largest breeding colonies in agricultural harvest." (Cook and Toft 2005)
> "We interpret our results to provide clear evidence that extinction is imminent for Tricolored Blackbird if current land-use trends continue, as they certainly will, and if measures are not implemented immediately to protect breeding colonies in non-native nesting substrates. Overall the current decline of the population is strongly correlated with its persistent use and re-use of attractive habitats where reproduction often fails, combined with continuing losses of productive nesting substrates of all kinds… The

protection of native emergent marshes is not the solution to reverse the declining population because this habitat provides attractive population sinks. Under current protections, Tricolored Blackbird may therefore be falling through the policy “cracks”, because it is not targeted directly as an officially endangered species and protecting its native breeding habitat under current environmental policy is not sufficient to reverse the declining population.” (Cook and Toft 2005)

“In 1994 and 2000 the top 10 colonies accounted for 60% and 59% of the total population estimate, respectively. In 2008, this has increased to 77.5%. This increase in concentration of individuals at fewer colonies increases the chances of reproductive failure for a significant proportion of the population in any given year.” (Kelsey 2008)

“This year’s population estimate represents a substantial decrease from 2008 of approximately 135,000 birds, or a 34% decline (far more than would have been missed by any gaps in coverage). This number is more similar to the population estimate in 2005. One important probable cause of this decline is low reproductive success that has been documented in reports over the past three years (Meese 2008, 2009a, 2010). Several of the largest colonies in recent years have had an average nest success rate of 0.25 young fledged per nest and the reproductive success of these colonies has been declining for several years... This may be a major factor in the observed population decline despite continued conservation efforts (Meese 2009a).” (Kyle and Kelsey 2011)

“The 2014 statewide survey is believed to have been the most thorough ever conducted. Concerned citizens have entered dozens of new location records into the Portal, resulting in a rapid increase in knowledge of where the birds breed, and the number of locations surveyed increased from 361 in 2008 to 802 this year. Yet despite this rapid increase in knowledge, the number of birds in California as estimated by the Statewide Survey again declined sharply.” (Meese 2014)

“Bird numbers were down markedly from the two previous statewide surveys in the San Joaquin Valley, especially in Kern and Merced counties, where the breeding birds had recently been most concentrated... Overall, the number of breeding birds in the San Joaquin Valley dropped 78% in 6 years, from 2008 to 2014…, and the number of birds seen in counties along the Central Coast was less than 10% of that seen in 2008...” (Meese 2014)

Graves et al. (2013) analyzed a dataset comprising 2463 records of the size of breeding colonies from 1907 to 2009. The resulting database included 1964 records of breeding or non-breeding birds from 1183 sites in 46 counties. The authors conducted a systematic statistical evaluation of trends for Tricolors to determine the magnitude of overall decline and whether it is continuing, whether trends were apparent across regions, whether trends varied among different types of breeding habitats, whether the geographic distribution of the species has changed, and if so whether distributional changes were linked to changes in habitat used for breeding.

Statewide, colony size, as indexed by the number of birds per record, declined significantly and substantially from 1935 to 1975 (Graves et al. 2013). The authors did not detect a decline in average colony size from 1980 to 2009, however, this may have been due to attempts to combine data that were not comparable. On a regional basis, both the number of birds per breeding site (colony) and total birds per region decreased drastically before and after 1980 (Figure 1). Regions included Central Coast, North Coast, Northeast Interior, Sacramento valley, San Francisco Bay, San Joaquin Valley, and Southern California.

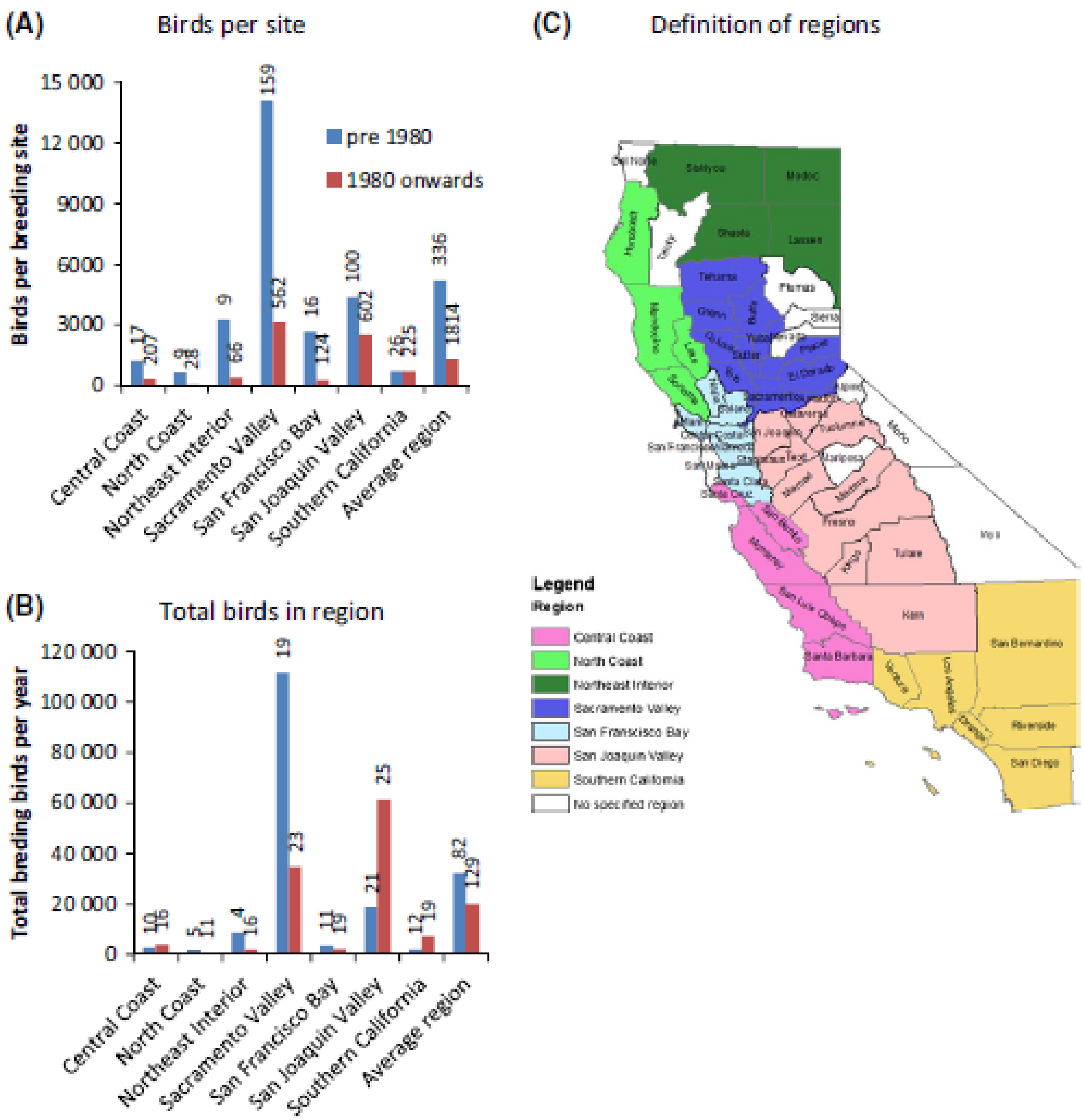

Figure 1: Number of Tricolored Blackbirds Per Breeding Site and Total Number of Breeding Birds Per Year Before and After 1980 By Region

There was evidence for geographical variation in the average size of breeding colonies over time. Prior to 1980, the Sacramento Valley supported far larger populations than any other region, while after 1980 the San Joaquin Valley held that distinction. One of the most hard-hit regions appeared to be the Central Coast. The authors noted on page 4: "In 1935 the Central Coast had 72% larger colonies than the average across all regions but subsequent to this these sites declined 80% more rapidly than colonies in other regions." Results of the 2014 statewide census survey showed continuing drastic declines in the Central Coast region, with the number of birds counted in that region were only 10% of those counted in 2008 (Meese 2014).

Since 2009 (the last year in the Graves et al. dataset), two more state-wide census surveys were conducted, and additional data were recorded during intervening years regarding colony sizes. The 2014 census reported a substantial downward trend in the sizes of the largest colonies over the past decade. Meese (2014:11) stated "A total of 93,000 birds was seen in the 10 largest colonies, 64% of the total. This is a much lower percentage of the total than was seen in the 10 largest colonies in 2011, when 208,800 birds, or 81% of the total, were seen in the 10 largest colonies, and in 2008, when 306,00 birds, 77.5% of the total, were seen in the 10 largest colonies." Figure 2 below shows the 10-year trend in the sizes of the largest colonies, from Meese (2014:11).

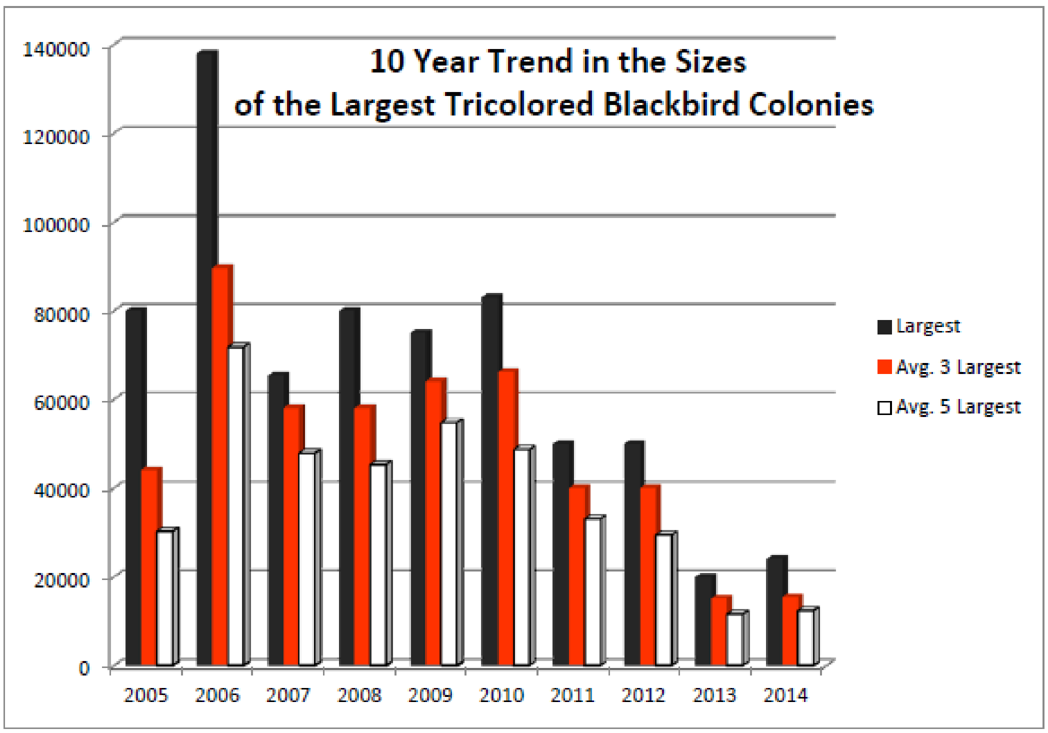

Figure 2: 10-Year Trend in Sizes of Largest Tricolored Blackbird Colonies

In addition to average colony size, the size of the largest colony has declined precipitously since the first reported surveys. Neff (1937) documented numerous large colonies, including one in

1934 in Glenn County that contained about 300,000 breeding adults over an area greater than 24 ha. Several other colonies in Sacramento and Butte Counties contained more than 100,000 nests. In stark contrast, Bob Meese reported that in 2014 the numbers of birds seen at occupied locations ranged from 1 to just 24,000, with only a single colony in Madera County (Road 12 Avenue 24) consisting of more than 20,000 birds and only 3 colonies consisting of 10,000 or more birds. This is a dramatic and extremely troubling decline in the size of the largest nesting colonies compared with historical data, even incorporating the recently described phenomenon of "mega" colonies nesting in silage crops, because forming large colonies is likely an adaptive trait against predation and colony size is positively correlated with reproductive success (Meese 2013). For a species such as the Tricolored Blackbird, bigger colonies are better.

In sum, extensive range-wide surveys for the Tricolor provide clear and unequivocal evidence that the species has experienced and is continuing to experience a precipitous population decline. Total numbers of birds counted, average colony sizes, and size of the largest colony all decreased over time. Further, as documented below, there is no evidence that many of the factors implicated in this decline are being prevented or alleviated, including ongoing destruction of grain silage colonies, failure to protect highly productive nesting substrates (i.e. Himalayan blackberry thickets, thistles, and other productive upland breeding habitats), permanent loss of nesting and foraging habitat due to increasing urbanization and vineyard and orchard deployment in the Central Valley and southern California, continued high levels of predation in marsh nesting habitats by herons and other predators, spraying of agricultural contaminants throughout the range of the species, and shooting of birds in rice fields in the Central Valley. Without the legal protection offered by the California Endangered Species Act, current trends are likely to continue and the Tricolor is likely to become extinct in the foreseeable future.

2.0 Range and Distribution

2.1 Species' Range

More than 99% of Tricolored Blackbirds live in California, with just a few scattered populations in Oregon, Washington, coastal Baja California, Mexico and a single breeding colony in western Nevada (Beedy and Hamilton 1999). The range of the Tricolor is largely restricted to southernmost Oregon and the Modoc Plateau of northeastern California, south through the lowlands of California west of the Sierra Nevada to northwestern Baja California (Neff 1937, Orians 1961a, DeHaven et al. 1975, Beedy and Hamilton 1999) with some rare reports from Nevada and Washington (Beedy and Hamilton 1999). The elevational range of the Tricolor is documented to extend from sea level to approximately 1220 meters (4,000 feet) in Shasta County to 1280 meters (4,200 feet) on Klamath Lake (Neff 1937). Although most of the Tricolor population and the largest colonies are currently found in the San Joaquin and Sacramento valleys, the species also breeds in several southern California counties where, a century ago, it was considered to be the most abundant bird species (Baird in Cooper 1870).

The range of the Tricolored Blackbird is similar to that reported early in the previous century although contractions in some areas, particularly southern California, are apparent as discussed below. Shuford and Gardali (2008: 438–439) describe the historical and recent range of the Tricolored Blackbird as follows:

> "The Tricolored Blackbird's known historical breeding range in California included the Sacramento and San Joaquin valleys, the foothills of the Sierra Nevada south to Kern County, the coastal slope from Sonoma County south to the Mexican border, and, sporadically, the Modoc Plateau (Dawson 1923, Neff 1937, Grinnell and Miller 1944). Historical surveys, however, did not include large areas of the species' currently known breeding range and consequently did not document its full extent at the time (see below)…
>
> "The overall range of the species is little changed since the mid-1930s (Beedy and Hamilton 1999), though more recent surveys have documented occurrence in some areas lacking extensive prior coverage that likely were occupied historically (Hamilton et al. 1995; Beedy and Hamilton 1997; Hamilton 2000, 2004; Green and Edson 2004). This mostly includes documentation of local populations at the periphery of the range, such as those on the coast north to Humboldt County, in northeastern California, and in the western Mojave desert, and of new colony sites within the overall historic range (see map). Since 1980, active breeding colonies have been observed in 46 California counties; all of the largest (>20,000 adults) were in the Central Valley or at the Toledo Pit, Riverside County [*sic*: Toledo Pit is in Tulare County]."

The southern California population (in the Los Angeles Basin, Inland Empire/Riverside, and San Diego regions south of the Transverse Range) appears to have been geographically isolated since the 1970s-1980s (R. Cook pers. comm.). There are no recent records from Santa Barbara or Ventura Counties and relatively small numbers in coastal Los Angeles and Orange County. While there have been from time to time, colonies of as much as 5000 birds in the very northern part of Los Angeles and San Bernardino Counties, those are undoubtedly due to migrations of flocks from the Central Valley (R. Cook pers. comm.).

Within its range, the species is nomadic and highly colonial; large flocks appear suddenly in areas from which they have been absent for months, they breed and then quickly withdraw (Orians 1961a). In one season nesting colonies have been found widely scattered, and in another there have been great concentrations in relatively restricted districts (Neff 1937). The size and location of colonies vary from year to year, although certain sites are regularly used (Orians 1961a, Hamilton et al. 1995, Cook 1996, Hamilton 2000, Kelsey 2008, Kyle and Kelsey 2011, Meese 2014).

Wintering Tricolored Blackbird populations move extensively throughout their range in the nonbreeding season. Major wintering concentrations occur in and around the Sacramento–San Joaquin River Delta and coastal areas, including Monterey and Marin counties, where they are often associated with dairies (Shuford and Gardali 2008). Small flocks also may appear at scattered coastal locations from Sonoma County south to San Diego County, and sporadically north to Del Norte County (Beedy and Hamilton 1999, Unitt 2004). They are rare in winter in the southern San Joaquin Valley and in the Sacramento Valley north of Sacramento County

(Beedy and Hamilton 1999). In Riverside County Tricolor populations appear to be residential with similar numbers of birds observed in winter in the same areas where they breed in the spring (R. Cook; unpublished data).

2.2 Historical Distribution

The Tricolor's requirements for selecting breeding sites are open accessible water; a protected nesting substrate, including either flooded or thorny or spiny vegetation; and a suitable foraging space providing adequate insect prey within a few kilometers of the nesting colony (Beedy and Hamilton 1999, Shuford and Gardali 2008). Historically, rivers flowing into the Central Valley would flood and create extensive marshes, providing abundant breeding habitat for Tricolors and other wetland-dependent species. In the 19th century, autumn flocks of thousands of Tricolors were described in the Shasta area, and a wintering flock observed in Solano County "...numbering so many thousands as to darken the sky for some distance by their masses," (Baird 1870 in Beedy and Hamilton 1999). J. G. Cooper noted that the Tricolor was "the most abundant species near San Diego and Los Angeles, and not rare at Santa Barbara," (Baird 1870 in Beedy and Hamilton 1999).

The first systematic range-wide surveys of the population status and distribution of the Tricolor were conducted by Neff (1937). These surveys found Tricolor breeding colonies in at least 26 counties in California, although the survey of the range was still incomplete. Neff (1937) estimated abundance at 252 colonies, mostly associated with freshwater emergent wetlands in rice-growing areas of California, and numerous very large colonies were reported.

Population surveys and banding studies carried out from 1969–1972 by DeHaven et al. (1975) found 168 breeding colonies at 113 locations, each at least 1.6 km apart. About 78% (131) of the colonies were in the Central Valley, with 80 in the Sacramento Valley and 51 in the San Joaquin Valley. The remaining 22% (37) of colonies were in other parts of California and in southern Oregon. The counties where the most colonies were found in a single season were Sacramento, Merced, Stanislaus, Glenn, and Colusa.

The survey results from DeHaven et al. (1975) indicated that the geographic range and major breeding areas of the species had not changed since the first surveys were conducted by Neff in 1937. However, DeHaven et al. (1975) found fewer colonies, fewer non-breeding Tricolors, no nesting areas even approaching the size of some of the previously reported colonies, fewer birds in the largest colonies, and fewer total Tricolors.

It is worth noting that even the earliest surveys had been conducted after most of the Central Valley's wetlands were already lost. Thus, the historical distribution and population abundance of Tricolors prior to the profound and widespread loss of their native wetland and grassland habitats are unknown.

2.3 Current Distribution

Overall, a comparison of the historical and current distribution of the species shows that in some portions of their range, Tricolors have declined or been eliminated (Beedy and Hamilton 1997). Local near or complete extirpation has occurred in portions of the Central Valley where the species was once abundant, and in many historical sites in coastal southern California counties, including Santa Barbara, Ventura, Los Angeles, Orange, and San Diego Counties (Beedy and Hamilton 1997, Meese 2014). Thus the species has been extirpated or nearly extirpated in portions of its former range.

Since 1980, active Tricolor breeding colonies have been observed in 46 counties in California, and most of the largest colonies are still located in the Central Valley (Beedy and Hamilton 1999). The species currently breeds throughout the Central Valley west of the Cascade Range and west of the Sierra Nevada (into the foothills), and from Humboldt and Shasta Counties, south to extreme southwestern San Bernardino County, western Riverside County, and western and southern San Diego County. Breeding also occurs in marshes of the Klamath Basin in Siskiyou and Modoc Counties, Honey Lake Basin in Lassen County and in some central California coastal counties.

Outside California, the Tricolor has bred in southern Klamath and southern Jackson Counties and in northeast Portland (Multnomah County), near Clarno and Wamic (Wasco County), at the John Day Fossil Beds National Monument (Wheeler County), near Stanfield (Umatilla County), and at Summer Lake (Lake County). A small colony reportedly nested in Grant County, Washington in 1998, and small colonies were identified in Douglas County, Nevada and in northern Baja California (Beedy and Hamilton 1999). Several small colonies totally fewer than 500 birds were reported in Baja California in 2013 (Feenstra 2013).

In 1991 researchers at U.C. Davis initiated a large-scale study of Tricolors, investigating size and location of colonies, nesting habitat characteristics, behavior, reproductive success as correlated with habitat type and patterns of land ownership. This study was expanded in 1994 to include a FWS and CDFW sponsored range-wide population census led by the U.C. Davis researchers and including a volunteer base of experienced local ornithologists. The results of this census and additional season long survey data are reported in Hamilton et al. (1995). Census participants located individuals nesting in 74 colonies in 32 California counties, with breeding occurring in 26 counties. In 1994, the largest Tricolor colonies were found in Merced, Colusa, Tulare, Glen, Kern, Sacramento, and Yuba Counties (Beedy and Hamilton 1997).

Annual population censuses were henceforth attempted in 1995 and 1996 but efforts and methods were not comparable to those of 1994. A second comparable census and additional season long surveys were conducted in 1997 using the same coverage, methods, and surveyors as in 1994 (Beedy and Hamilton 1997). Census results reported individual Tricolors in 32 California counties, including 50 non-breeding adults in Klamath County, Oregon, and 950 breeding adults in northwestern Baja California.

In 1997, the largest Tricolor colonies were found in Colusa, Tulare, Kings, Riverside, Kern, Sacramento, and San Joaquin Counties (Beedy and Hamilton 1997). The two largest observed colonies during the 1997 breeding season were found in Colusa and Tulare Counties. The Colusa County colony formed in May, after the volunteer survey ended, by birds that probably nested elsewhere earlier on in the season. One of the largest colonies found in 1997, of about 23,300 nests, was found at a wetland created in 1994 in San Jacinto, Riverside County. "Although Riverside remains the stronghold for the species in southern California, numbers have declined by 89% since 1997 and 66% since 2005." (R. Cook, 2014).

During the 2000 census, 25 colonies were located, with the largest colonies occurring in Tulare, Merced, Riverside, and Colusa counties. It is notable that the large colonies that formed in Sacramento county in the early 1990s (including 1994) were absent in surveys conducted between 1997 and 2003.

During the 2008 survey, 135 breeding colonies were documented, with the largest "mega" colonies in Merced, Tulare, and Kern counties, all in the San Joaquin Valley. Again, very large colonies were absent from Sacramento county (Kelsey 2008). In 2011 the three largest concentrations of birds also were found in Merced, Kern, and Tulare counties, with 65% of the population consolidated into only six colony sites in these three counties (Kyle and Kelsey 2011). In 2014, the largest nesting colonies occurred in Tulare, Madera, and Merced counties, but these colonies all supported drastically fewer numbers of Tricolors than in the previous two census surveys (Meese 2014). However, Placer and Sacramento counties saw a marked increase in the number of birds (Meese 2014).

The number of birds observed differed markedly by bioregion in 2014, Southern California (Ventura, the far southern part of Kern, Los Angeles, Orange, San Bernardino, Riverside, and San Diego counties) had 12,386 birds, the San Joaquin Valley (from Kern County in the south to San Joaquin County in the north) had 73,412 birds, coastal locations (from Alameda County to Santa Barbara County) had 1,732 birds, the Sierra foothills (Amador, Calaveras, El Dorado, Placer, and Sacramento counties) had 25,717 birds, and the Sacramento Valley (from Yolo County in the south to Tehama County in the north) had 31,531 birds.

Table 1 below shows the locations surveyed, locations occupied, number of birds, and proportion of total from the most recent statewide census survey in 2014 (Meese 2014:8).

Table 1: Locations Surveyed and Occupied, Number of Tricolored Blackbirds, and Proportion of Total by County (Meese 2014 Table 1:8)

County	Locations Surveyed	Locations Occupied	Number of Birds	Proportion of Total
Alameda	27	1	50	0.034
Amador	6	2	5500	3.793
Butte	6	1	60	0.041
Calaveras	9	5	404	0.279

Colusa	23	0	0	0
El Dorado	9	5	1375	0.948
Fresno	25	1	6	0.004
Glenn	29	1	300	07207
Kern	64	12	3977	2.743
Kings	15	1	5000	3.448
Lake	6	1	150	0.103
Lassen	2	1	232	0.16
Los Angeles	11	6	4707	3.246
Madera	10	2	27166	18.735
Mariposa	1	1	13	0.009
Mendocino	5	1	100	0.069
Merced	46	5	10532	7.263
Monterey	22	6	399	0.275
Napa	11	1	70	0.048
Orange	17	1	14	0.01
Placer	20	4	17600	12.138
Riverside	28	9	4368	3.012
Sacramento	98	19	29272	20.188
San Benito	13	1	80	0.055
San Bernardino	10	6	1380	0.952
San Diego	30	6	1417	0.977
San Joaquin	9	2	515	0.355
San Luis Obispo	29	5	98	0.068
Santa Barbara	18	7	935	0.645
Santa Clara	6	0	0	0
Santa Cruz	8	0	0	0
Shasta	15	1	250	0.172
Solano	15	3	610	0.421
Sonoma	4	0	0	0
Stanislaus	36	10	8852	6.105
Sutter	18	1	8	0.006
Tehama	5	2	300	0.207

Tulare	30	5	18259	12.592
Tuolumne	8	3	825	0.569
Yolo	33	2	81	0.056
Yuma	25	3	268	0.185

The largest numbers of breeding Tricolors were historically found in the Central Valley; Orians (1961a) and DeHaven et al. (1975) reported that the species' center of breeding abundance and the largest colonies were in this region. In 1994 and 1997, more than 75% of all breeding adults were located there (Beedy and Hamilton 1997). In 2000 approximately 70% of the population was located in the Central Valley (Hamilton 2000). In 2008, 86.4% of the population was found in the San Joaquin Valley, and in 2011, 89% of the population occurred in the San Joaquin Valley and Tulare Basin. However, in the 2014 census only 50% of the population was documented in the San Joaquin Valley, with more birds counted in the Sacramento Valley than at any time since the 1990s. Meese (2014:10) stated "the 29,272 birds seen in Sacramento County exceeded the total seen in any statewide survey since 1997, when 31,338 birds were seen in the county (Beedy and Hamilton 1997)." Yet the numbers of birds counted in the Sacramento Valley are still a fraction of the hundreds of thousands of birds documented in the 1930s by Ness.

A detailed Distribution Map is provided below in section 11.

3.0 Abundance

3.1 Historical Abundance

Shuford and Gardali (2008: 438) describe the historical abundance of the Tricolored Blackbird as follows:

> "Few 19th-century accounts exist of the abundance of Tricolored Blackbirds in California. Heermann (1859:53) described fall flocks of thousands in the Shasta region and a wintering flock in Solano County "numbering so many thousands as to darken the sky for some distance by their masses." Belding (1890) observed an "immense" colony in San Joaquin County. According to J. G. Cooper, the Tricolored Blackbird was "the most abundant species near San Diego and Los Angeles, and not rare at Santa Barbara" (Baird 1870:266; Baird et al. 1874:166). Grinnell (1898) reported them in "considerable numbers" throughout the year in Los Angeles County.
>
> "Neff (1937) conducted the first systematic surveys of the species' population status and distribution. In 1934, he observed as many as 736,500 adults in just eight Central Valley counties. From 1931 to 1936, he found 252 colonies in 26 California counties. The largest colony, in Glenn County, contained >200,000 nests (about 300,000 adults) and covered almost 24 ha; several others in Sacramento and Butte counties contained

>100,000 nests (about 150,000 adults). Most large colonies were associated with freshwater emergent wetlands in rice-growing areas of the Sacramento Valley."

3.2 Current Abundance

Meese (2014) noted that "the rate of decline in the number of tricolors appears to be increasing. From 2008 to 2011 the number of tricolors dropped by 34%, from 395,000 to 258,000 birds (Kyle and Kelsey 2011), but from 2011 until this year the number of tricolors dropped by 44%, from 258,000 to 145,000 birds." Figure 3 below shows the downward trend in abundance during the three recent statewide surveys, from Meese (2014:7). The total number of Tricolors counted was down 44% in 3 years, and 64% in 6 years.

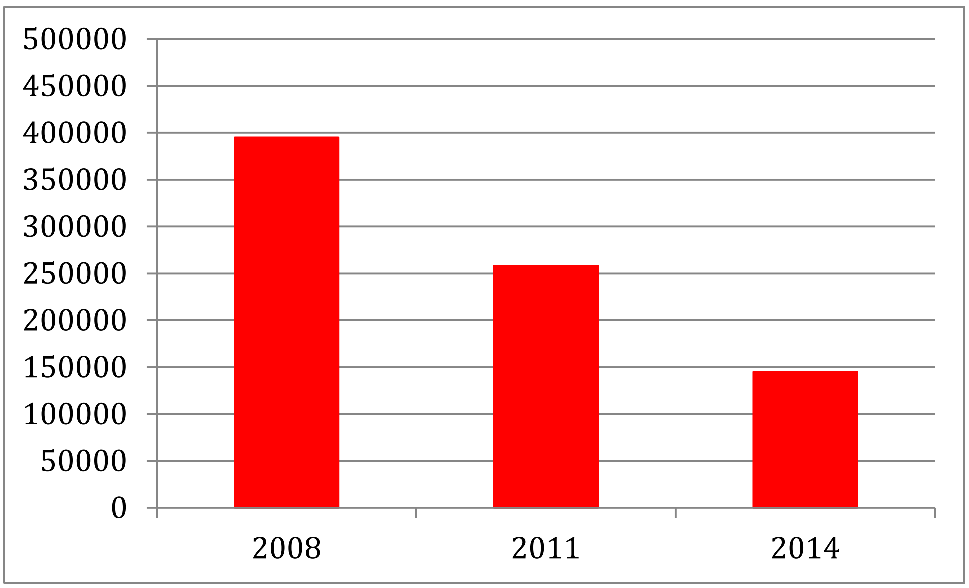

Figure 3: Trends in Abundance of Tricolored Blackbirds from Census Surveys

Meese (2014:12) summed the troubling results of the three most recent statewide surveys, which represent the best estimates of the abundance of Tricolored Blackbirds over the past decade:

> "The results of the 2014 Tricolored Blackbird Statewide Survey show that there are far fewer birds now than in the recent past. The results of the past 3 statewide surveys (2008, 2011, and 2014) are most directly comparable due to similar methods and levels of effort . . . . And the development of the Tricolored Blackbird Portal in 2008 provided a previously unavailable public resource that has met the needs of concerned citizens and encouraged their participation in tricolored blackbird conservation efforts while greatly improving data quality and management.

> “The rate of decline in the number of tricolors is alarming and appears to be accelerating: a comparison of the results of the 2008 to 2011 interval shows that the number of tricolors declined by 34%, from 395,000 to 258,000 birds. But from 2011 to 2014 the number of birds declined by 44%, from 258,000 to 145,000 birds…Thus, conservation efforts to date have been insufficient to stem the decline in the number of tricolors and the rate of decline is increasing.”

4.0 Life History

The highly synchronous and colonial nesting behavior of the Tricolored Blackbird is likely an adaptation that increases reproductive success through predator saturation and mutual defense against predators (Cook and Toft 2005). Much fascinating information has been learned about the adaptive traits of highly colonial nesting birds from studies of the Tricolor, beginning in the 1960s. The Tricolored Blackbird portal administered by U.C. Davis states:

> “In the 1960’s, two graduate students from U.C. Berkeley, Gordon Orians and Robert Payne, conducted seminal research on blackbirds, including Tricolors, that focused on behavior and adaptations for marsh nesting (Orians) and reproductive physiology (Payne) and helped to provide an ecological and evolutionary context for tricolor breeding, food preferences, and habitat selection and compared and contrasted tricolors with other blackbird species.
>
> “In the late 1960’s, Frederick Crase, a Bureau of Reclamation biologist, and Richard DeHaven, who worked for the U.S. Fish & Wildlife Service, began working on the tricolored blackbird and studied food habits, habitat relationships, population status, and movement patterns. This work was described in a number of publications from the mid-1970’s until the late 1980’s. This work confirmed the continuing decline in the number of tricolored blackbirds and highlighted the dependence of food supplies, especially insect abundance, on colony productivity, and suggested that otherwise apparently suitable nesting sites might be abandoned if surrounding foraging habitats were not sufficiently productive or extensive.”

The portal further notes that in the 1980s Ted Beedy began field investigations of Tricolors with an emphasis on estimating the abundance of the species and determining factors responsible for the observed nesting failures of colonies in the Central Valley. Shortly thereafter, Bill Hamilton began his field investigations. Hamilton's work continued for 13 field seasons, through 2005, and covered topics such as population estimation, productivity estimation, foraging ecology, and the phenomenon known as “itinerant breeding,” whereby individuals breed once in one location and then fly northward to a different location to breed again. Hamilton’s graduate student, Liz Cook, conducted and published important work on nesting dynamics, and his colleague Bob Meese began banding studies in 2007 and reported extensively on colony fates and productivity. These studies are described below.

4.1 Species Description

The Tricolor is medium-sized and sexually dimorphic, breeding in dense colonies largely in California's Central Valley, Coast Ranges, and southern California (Beedy and Hamilton 1999). Total length ranges from 18-24 cm, and body mass ranges from 40–70 g depending on the season (Beedy and Hamilton 1999).

The sexes of the Tricolor differ in size, plumage and behavior. Beedy and Hamilton (1999) offered a detailed description of the species:

> "In general, males are larger than females; have striking red, white, and black plumage; and display when breeding. Adult males are entirely black with a blue gloss in full sunlight, with bright brownish-red lesser wing coverts forming a red patch on the epaults (wing shoulder), and median coverts buffy (August-February) to pure white (February-July), depending on the season. Adult females are mostly black with grayish streaks, relatively whitish chin and throat (rarely with faint pinkish or peach wash), and small but distinct reddish shoulder patch. Immature males are similar to adult males but with duller black plumage mottled with gray (August-March), becoming almost entirely dull black (April-June), and with shoulder patch mixed with black (August-March only). Immature females are similar to adult females but the wing lacks the reddish patch. Immatures of both sexes usually retain some brownish or grayish underwing coverts, which contrast with newer adjacent black feathers. Juveniles of both sexes (April-August) are similar to adult females, but much paler gray and buff."

The plumage of the Tricolor and Red-wing is so similar that museum specimens are sometimes misidentified (Orians 1961a). The adult male Tricolor has a bluish luster to its black plumage, and the red of the epaulets is bright scarlet in contrast to the dull orange-red of the male Redwing (Orians 1961a). Both sexes of Tricolors are distinguished from Red-wings by bill shape, tail shape, and primary feathering formula; the outermost primary (P9) is longer than P6 in Tricolors and shorter in Red-wings (Beedy and Hamilton 1999). In addition, Tricolors have longer outer primaries, creating a narrower and more pointed wing shape than other blackbirds (Beedy and Hamilton 1999). The most conspicuous feature of the male plumage is the broad white border to the middle wing coverts (Orians 1961a).

In most races of the Red-wing these feathers are tipped with buffy, but in those races occupying the central Coast Ranges and Central Valley of California, where the Tricolor is most abundant, these feathers are black so that the wing lacks the light-colored stripe (Orians 1961a). Orians (1961a) noted that "[t]his plumage difference between males is not only conspicuous to the human observer, it is the most important means of species identification used by the birds themselves. Occasional Red-wings in a flock of Tricolors are singled out for special attack by a resident male Redwing in whose territory the flock lands." Orians (1961a) also described the difference between female Tricolors and Red-wings: "[i]n general, female Tricolors are more uniformly sooty than female Redwings, there being less contrast between throat and breast. In the autumn, female Redwings are strongly tinged with rusty on the back, a feature never shown by the female Tricolor." Females of both species are more difficult to distinguish because, although female Tricolors are darker than most races of the female Red-wing, female Red-wings are actually the darkest in the region of distributional overlap. Interestingly, there appears to be a convergence of female plumage where the two species overlap, in contrast to a divergence of plumage in the males (Orians 1961a).

Sexual dimorphism in size is less in the Tricolor than in the Red-wing. Male Tricolors are smaller than male Red-wings in wing, tail, tarsus, and bill depth, but are larger in culmen, whereas female Tricolors are larger than female Red-wings in wing, tail, tarsus, and culmen, but are smaller in bill depth (Orians 1961a). This longer, narrow bill of the Tricolor is one of the most reliable morphological differences between the species (Orians 1961a).

Flight of the Tricolor consists of long, shallow undulations and flocks tend to be compact (Beedy and Hamilton 1999).

4.2 Taxonomy and Population Genetics

Mitochondrial DNA (cytochrome *b*) studies indicate that the nine *Agelaius* species are a polyphyletic assemblage of ecologically similar species (Beedy and Hamilton 1999). . "Within *Agelaius sensu lato*, *A. tricolor* clusters with four species, what might be called the true *Agelaius* (i.e., *sensu stricto*): *A. phoeniceus* (the Red-winged Blackbird of North and Central America), *A. assimilis* (the Red-shouldered Blackbird of western Cuba), *A. humeralis* (the Tawny-shouldered Blackbird of Hispaniola and Cuba), and *A. xanthomus* (the Yellow-shouldered Blackbird of Puerto Rico) (Lowther et al. 2004)." (Meese et al. 2014).

Behavioral difference between the Central Valley and southern California populations and an absence of exchange of individual banded birds between the two areas suggests the Tehachapi Mountains may act as a potential dispersal barrier (Berg et al. 2010). Elena Berg and colleagues at U.C. Davis used two complementary molecular markers, nuclear DNA microsatellites and mitochondrial DNA sequences, to examine the genetic structure of seven colonies of Tricolored Blackbirds in the Central Valley. Microsatellites evolve rapidly and are highly variable, and therefore are effective at determining the amount of gene flow among populations. In contrast, maternally inherited mitochondrial DNA (mtDNA) does not recombine, thus allow the description of historical changes in population size (by detecting maternal bottlenecks) and temporal variation in gene flow. The researchers found no evidence for population structuring within the seven areas, suggesting that the Central Valley colonies are a single population at the genetic level.

Berg and colleagues then used similar techniques to determine whether gene flow occurred between northern and southern populations, and whether there was population structuring within the southern populations (Berg et al. 2010). Microsatellite and sequencing results revealed no evidence of significant population structuring between the southern California and Central Valley Tricolor populations, indicating either considerable movement and genetic exchange between regions and few if any isolated populations, or that any isolation is very recent and not yet reflected in the population genetic signatures. Furthermore, the higher allelic diversity of the southern California population, despite its smaller overall population size compared to the

Central Valley population, suggests that the southern California population is an important reservoir of genetic variation for the species overall (Berg et al. 2010). Berg et al. (2010) noted however that "the genetic signature of a recent and dramatic decrease in effective population size in southern California is of high concern, since it suggests that despite the lack of evidence for recent bottlenecks in this species, there are many fewer birds breeding in southern California than in the recent past."

4.3 Reproduction and Growth

Males begin singing as early as late February. Nesting is initiated in late March to early April, primarily in the San Joaquin Valley, and again in May to June in the rice-growing region of Sacramento Valley and foothill areas (Hamilton 1998, Beedy and Hamilton 1999). Male Tricolors may arrive before females at the colony sites, but sometimes by less than one day, and sometimes both sexes arrive together and begin breeding activity the same day (Beedy and Hamilton 1999). Dense concentrations of birds will gather and suddenly fly to another place, changing locations frequently and then returning to potential nest sites. This is described as "prospecting behavior" (Beedy and Hamilton 1999). Requirements for breeding colony sites are accessible water, protected nesting sites such as flooded or spiny, stinging, or otherwise armored or protective vegetation, and adequate amounts of suitable foraging areas within a few kilometers of the nesting colony (Beedy and Hamilton 1997). Most adults at a colony site begin nesting 2–3 days after prospecting begins. When Tricolors arrive at a breeding site, previously established breeding Red-wings and Yellow-headed (*Xanthocephalus xanthocephalus*) blackbirds may be excluded from territories by extremely large numbers of Tricolors.

Females construct their nest within the small territory of the male, and one male will breed with 1–4 females (Beedy and Hamilton 1999). Extreme synchrony is characteristic of most colonies of Tricolors—even in colonies of up to 100,000 nests, all eggs may be laid within one week (Orians 1961a). Males do not assist with nest construction or incubation, but do assist with food gathering and feeding of the young.

During the breeding season, Tricolors exhibit itinerant breeding whereby individuals often move after their first nesting attempts and breed again at a different geographical location (Hamilton 1998). At some colonies a second wave of nesting follows fledging of the initial cohort (Beedy and Hamilton 1999).

4.4 Diet and Foraging Ecology

Tricolors are opportunistic foragers, taking any locally abundant insect including grasshoppers (Orthoptera), beetles and weevils (Coleoptera), caddis fly larvae (Trichoptera), moth and butterfly larvae (Lepidoptera), dragonfly larvae (Odonata), and lakeshore midges (Diptera), as well as grains, snails, and small clams (Beedy and Hamilton 1999). In earlier studies Tricolors were described as grasshopper followers (Orians 1961b; Payne 1969) and losses of grasslands and reduced grasshopper abundance may have contributed to the decline of the Tricolor population observed between the 1930s and 1970s (Crase and DeHaven 1977). Recently, however, grasshoppers have been abundant enough locally to support some large Tricolor colonies (Meese 2013).

Tricolors forage in all seasons in pastures, dry seasonal pools, agricultural fields including alfalfa with continuous mowing schedules, rice fields, feedlots, and dairies (Beedy and Hamilton 1997). The birds will also forage in riparian scrub, saltbush (*Atriplex* spp.) scrub, borders of marshes, and grasslands. They do not forage regularly in weed-free row crops and intensively managed orchards and vineyards (Beedy and Hamilton 1997). Rangeland that is not heavily grazed is also important foraging habitat for Tricolors in some portions of their range (Cook 1996).

Adult Tricolors, when foraging for themselves, will consume the most easily obtained food; in many agricultural settings, this means the utilization of feed grains provided to livestock in feeding troughs and/or stored silage (e.g., cracked corn, sometimes available in huge quantities). Where such animal feeds are not available, as in colonies situated outside of livestock rearing areas, adults typically foraged close to the colony on abundant and easily-obtained foods such as spilled rice and unharvested grains (Hamilton and Meese 2006).

The hatching of eggs results in an immediate shift to foraging for animal prey. Foraging behavior exploits the most-abundant and most easily obtained foods that meet immediate dietary needs of nestlings. Animal matter is essential for 0–9 day old nestlings but grains and seeds are utilized by adults and > 9-day-old nestlings. Animal prey fed to nestlings is diverse, including caterpillars of several Lepidopteran species, grasshoppers, aquatic larvae of water scavenger beetles (Coleoptera: Hydrophilidae), midges, beetles, and other invertebrates (Hamilton and Meese 2006).

Hamilton and Meese (2006) found that when foraging for themselves, adults rarely travel more than 3 km from breeding colonies, and frequently take advantage of super-abundant food resources at or near dairies (e.g., stored grains, cracked corn, livestock feed) but will travel greater distances, occasionally more than 8 km, in search of animal prey with which to feed their young. Occasional forays of up to 13 km from the colony have been documented (Beedy and Hamilton 1997), although sustained short-distance foraging within sight of the colony is also observed (Cook 1996). There are some indications that the size of the foraging arena may correlate to nestling starvation as adults travel longer distances to find food (Liz Cook, pers. comm.).

Only a portion of the area within commuting distance from the nest is used for foraging. Many unsuitable areas, including cultivated row crops, orchards, vineyards, and heavily grazed grasslands, are associated with high-quality Tricolor foraging habitat such as irrigated pastures, lightly grazed rangelands, dry seasonal pools, mowed alfalfa, fields, feedlots, and dairies (Beedy and Hamilton 1999, Hamilton and Meese 2006). Wintering Tricolors in the Sacramento Valley appear to forage heavily on the seeds of plants such as rice, grains, and weeds (Crase and DeHaven 1978).

Orians (1961a) demonstrated that the Tricolor's colonial social structure is more energetically demanding than the territorial structure of the Red-wing due to the high energetic requirements of flying back and forth from distant feeding sites when foraging for young. Tricolors require food supplies that can be rapidly exploited once they reach the feeding site. Thus, the species has an unpredictable breeding distribution and poorer reproductive success than the Red-wing in unfavorable years (Orians and Collier 1962).

4.5 Mortality and Population Regulation

Band recovery data suggest that Tricolors live at least 13 years, although data are currently insufficient to estimate survival rates. Bob Meese of U.C. Davis initiated a number- and color-banding program in 2007. The color-banding continued until 2009 and the banding with USGS aluminum bands has continued through 2014 and has resulted in the banding of nearly 57,000 birds and the recapture of over 1,100 unique individuals. His band and re-sight samples of birds with number bands have been used to estimate an average annual adult survival of 60% (Meese unpub.).

Known causes of mortality include exposure to inclement weather (see "Other Natural or Anthropogenic Factors"); predation (see "Disease and Predation"); starvation (Meese 2010) and possible brood reduction via removal of live chicks from nests by females (Hamilton et al. 1995); competition with other species, including Great-tailed Grackles (*Quiscalus mexicanus*) which are aggressive towards Tricolors and may represent a serious future threat (Beedy and Hamilton 1999); agricultural contaminants and shooting for crop protection (see "Other Natural or Anthropogenic Factors"); widespread destruction of nesting substrate during the nesting season that results in direct mortality of nestlings, as well as historical and ongoing loss of nesting and foraging habitat (see "Present Or Threatened Destruction, Modification, or Curtailment of Habitat or Range").

5.0 Kind of Habitat Necessary for Survival

The Tricolored Blackbird forms the largest breeding colonies of any North American landbird (Cook and Toft 2005). As many as 20,000 to 30,000 nests have been recorded in cattail (*Typha* spp.) marshes of 4 hectares or less, with individual nests <0.5 meters from each other (Neff 1937, DeHaven et al. 1975b). Nest heights range from a few centimeters to about 1.5 meters above water or ground at colony sites in freshwater marshes (Neff 1937) and up to 3 meters in the canopies of willows (*Salix* spp.) and other riparian trees; rarely, they are built on the ground. The Tricolor's basic requirements for selecting breeding sites are open accessible water; a protected nesting substrate, including either flooded or thorny or spiny vegetation; and a suitable foraging space providing adequate insect prey within a few kilometers of the nesting colony (Beedy and Hamilton 1999, Shuford and Gardali 2008).

Tricolors are nomadic and highly colonial, and males defend relatively small territories within the colony (Orians and Collier 1962). Territories average about 35 square feet, or 1.8 m^2 to 2.35 m^2 in size, and one to three females construct nests within these small territories (Orians and Collier 1962, Beedy and Hamilton 1999). Unlike Red-wing Blackbirds, who gather food on and adjacent to their territories which average about 500–30,000 square feet in size, Tricolors do not forage on their territories but exploit the area around the colony (Orians and Collier 1962).

Historically most Tricolored Blackbird colonies were in the extensive native marshlands, riparian shrubs, upland shrubs, and grasslands of California, but the loss of these native habitats has forced a shift in nesting to largely non-native vegetation. Shuford and Gardali (2008:439–440) stated:

> "The colonial breeding system of the Tricolored Blackbird probably evolved in the Central Valley, where the locations of surface waters and rich sources of insect food were ephemeral and varied annually (Orians 1961). Before its rivers were dammed and channelized, the Central Valley flooded in many years, forming a vast mosaic of seasonal wetlands, freshwater marshes, alkali flats, native grasslands, riparian forests, and oak savannas. Virtually all these habitats once supported nesting or foraging Tricolored Blackbirds. The evolution of a colonial breeding system enabled this species to assess changing local conditions rapidly and exploit outbreaks of locusts and other ephemeral insects over large areas to meet their food demands. Nomadic, colonial social organization in birds evolves most frequently in semiarid areas with great annual fluctuations in climate (Orians 1961).
>
> "With the loss of a natural flooding cycle and most native wetland and upland habitats in the Central Valley, Tricolored Blackbirds now forage primarily in artificial habitats. Ideal foraging conditions for this species are created when shallow flood-irrigation, mowing, or grazing keeps the vegetation at an optimal height (<15 cm). Preferred foraging habitats include crops such as rice, alfalfa, irrigated pastures, and ripening or cut grain fields (e.g., oats, wheat, silage), as well as annual grasslands, cattle feedlots, and dairies (Beedy and Hamilton 1999). These blackbirds also forage in remnant native habitats, including wet and dry vernal pools and other seasonal wetlands, riparian scrub habitats, and open marsh borders. Vineyards, orchards, and row crops (tomatoes, sugar beets, corn, peas, beets, onions, etc.) do not provide suitable nesting substrates or foraging habitats for Tricolored Blackbirds."

Most Tricolored Blackbirds forage within 5 km of their colony sites (rarely up to 13 km; Orians 1961, Beedy and Hamilton 1997). Proximity to suitable foraging habitat may be a determinant in the establishment of colony sites, as Tricolored Blackbirds often forage, at least initially, in the field containing the colony site (Cook 1996). However, often only a minor fraction of the area within the commuting range of a colony provides suitable foraging habitat (Beedy and Hamilton 1999, Hamilton and Meese 2006).

Itinerant breeding of Tricolors suggests that they may be philopatric to more than one nesting site (Beedy and Hamilton 1999). Hamilton et al. (1995) found that 19 of 72 (26%) colonies used the same nesting sites during surveys conducted between 1992 and 1994. Eleven (15%) colonies in 1994 repeated either their 1992 or 1993 nesting location but not both. These results may indicate a low to moderate degree of site tenacity and/or that suitable breeding habitat is limited (Cook and Toft 2005). The yearly shifts in breeding distribution of Tricolors are likely related to insect supplies and other unknown breeding requirements (DeHaven et al. 1975).

Wintering Tricolored Blackbirds often congregate in huge, mixed-species blackbird flocks that forage in grasslands and agricultural fields with low-growing vegetation and at dairies and feedlots (Shuford and Gardali 2008). In February, however, this species segregates into pure Tricolored Blackbird flocks, which may subdivide further into age- and sex-specific flocks (Shuford and Gardali 2008). At this time, foraging flocks roam across the landscape until they find a suitable nesting substrate with an abundant insect source nearby.

Historically, nesting substrate consisted mostly of native emergent marsh vegetation dominated by cattails *(Typha* spp.) or tules (*Scirpus* spp; Neff 1937). Neff (1937) documented about 93% of nests (n = 252 colonies) in cattails, bulrushes and willows (*Salix* spp.) with some in nettles (*Urtica* spp.) and thistles (*Cirsium* spp.). However, Tricolors have been flexible in their choice of nesting substrates and have shown an increasing trend towards use of upland substrates for nesting following the 1930s, and many of these new substrates consisted of non-native plant species that would not have been present in the California landscape prior to the arrival of Europeans (Cook and Toft 2005). As noted by Cook and Toft (2005), the apparent shift from using wetland to upland habitats is "surely due to the loss of 96% of California wetlands over the last 150 years from 1,500,000 ha before European settlement." The use of freshwater marshes as breeding colony sites decreased from 93% in the 1930s (Neff 1937) to 54% (n = 158 colonies) in the 1970s (DeHaven et al. 1975b). Orians (1961a) found 64% of colonies in the Sacramento Valley nesting in cattails and other emergent vegetation; other nests were in agricultural fields, and one colony nested in trees along a river. DeHaven et al. (1975) reported that about 69% of colonies had nests built in marsh vegetation including cattails, bulrushes, willows, or some combination, and 49% were in cattails only.

Within the Central Valley, DeHaven et al. (1975) also documented breeding colonies in the rice-growing regions of the Sacramento Valley and in the pasturelands of the lower Sacramento Valley and San Joaquin Valley. In the rice lands, the annually flooded rice was the dominant crop, but small grains, hay, safflower, sugar beets, corn, and beans were also grown. The pasturelands consisted largely of irrigated fields of introduced grasses, alfalfa, hay, and small grains. In both areas, insects in flooded fields probably provide the primary food for breeding Tricolors. Colonies outside the Central Valley were found in a diverse array of habitat types, including within chaparral covered hills (Riverside and Colusa Counties), orange and avocado groves interspersed with grass-covered hills (San Diego County), sagebrush grasslands (Siskiyou County), and salt-marsh habitat of San Francisco Bay (Alameda County) (DeHaven et al. 1975).

An increasing percentage of colonies since the 1970s have been reported in Himalayan blackberry (*Rubus armeniacus*) and thistles (DeHaven et al. 1975b, Hamilton et al. 1995, Cook 1996). The most commonly used substrates today include native emergent marshes, grain silage at dairies, and Himalayan blackberry. Other less commonly used nesting substrates include safflower (*Carthamus tinctorius*), tamarisk (*Tamarix* spp.), elderberry/Western Poison Oak (*Sambucus* spp. and *Toxicodendron diversilobum*), Giant Reed (*Arundo donax*), and riparian scrublands and forests (e.g., *Salix* spp., *Populus* spp., *Fraxinus* spp.; Beedy and Hamilton 1999, Shurford and Gardali 2008).

In recent decades some of the largest Tricolor colonies have been found in triticale and other grain fields in the San Joaquin Valley (many of which are planted for silage) (Collier 1968, Hamilton et al. 1995, Beedy and Hamilton 1999, Meese 2006). The largest colonies occur in fields of triticale, a wheat-rye hybrid the name of which is an acronym of *Triticum* [wheat] and *Secale* [rye]. These fields of triticale are frequently harvested while nests are still active (Cook and Toft 2005, Meese 2007, 2008, 2009a, 2011). In 1994 approximately 40% of all breeding birds located throughout the nesting season were found in silage grain fields while approximately 47% nested in native emergent marshes and 31% in thickets of the introduced Himalayan blackberry (Cook and Toft 2005). In 2000, 17% of the breeding effort occurred in silage grain fields, while 54% of nesting was in emergent marsh and 12% in Himalayan blackberry, and additional colonies nested in other flooded and upland habitats. In 2014, 41% of nesting substrate was Himalayan blackberry and 38% was triticale, with cattails making up only 8.8% (Meese 2014:9; Table 2 below).

Graves et al. (2013) examined records from all surveys conducted from 1907 until 2009, portrayed in Table 2 below. For all records, the dominant breeding habitat was cattails, which comprised 48% of breeding records and 65% of breeding birds. Triticale was also important, with 9% of birds but only 1% of records due to the very large colony sizes (and only appearing as a substrate in recent years since it was not planted in earlier years). Bulrushes contained 7% of breeding birds and 9% of records. Other important upland breeding vegetation included Himalayan blackberry with 6% of breeding birds and 11% of records, and thistles with 5% of birds and 9% of records.

Table 2: Number of Records and Total Number of Breeding and Non-breeding Tricolored Blackbirds in Different Vegetation Types, 1907–2009 (Graves et al. 2013 Appendix A1:14)

	Total		Breeding		Non breeding	
Habitat	**Records (%)**	**Total birds (%)**	**Records (%)**	**Total birds (%)**	**Records (%)**	**Total birds (%)**
Cattails	400 (34%)	2,848,874 (53%)	326 (48%)	1,843,704 (65%)	74 (14%)	1,005,170 (43%)
Unknown	209 (18%	238,137 (5%)	19 (3%)	74,968 (2%)	190 (35%)	163,169 (7%)
Blackberry	157 (13%)	648,137 (12%)	72 (11%)	175,518 (6%)	85 (16%)	472,619 (20%)
Bulrush or tule	95 (8%)	380,706 (7%)	63 (9%)	202,550 (7%)	32 (6%)	178,156 (8%)
Thistles	83 (7%)	227,486 (4%)	59 (9%)	142,850 (5%)	24 (4%)	84,636 (4%)
Stinging nettle	47 (4%)	65,263 (1%)	32 (5%)	19,000 (1%)	15 (3%)	46,263 (2%)
Grassland	36 (3%)	8085 (0.2%)	0 (0%)	0 (0%)	36 (7%)	8085 (0.3%)
Grain fields						
Triticale	14 (1%)	437,300 (8%)	8 (1%)	261,650 (9%)	6 (1%)	175,650 (7%)

Rice paddy	13 (1%)	8027 (0.2%)	5 (1%)	3150 (0.1%)	8 (2%)	4877 (0.2%)
Barley	5 (0.4%)	15,540 (0.3%)	1 (0.1%)	4000 (0.1%)	4 (1%)	11,540 (1%)
Wheat	6 (0.4%)	78,775 (2%)	6 (1%)	45,500 (2%)	0 (0%)	33,275 (1%)
Other grain fields	4 (0.3%)	6625 (0.1%)	1 (0.1%)	6000 (0.2%)	3 (1%)	625 (0.03%)
Agricultural fields						
Pasture	22 (2%)	37,801 (1%)	0 (0%)	0 (0%)	22 (4%)	37,801 (2%)
Mustard	18 (2%)	106,667 (2%)	6 (1%)	65,250 (2%)	12 (2%)	41,417 (2%)
Feedlot	6 (1%)	3713 (0.1%)	0 (0%)	0 (0%)	6 (1%)	3713 (0.2%)
Alfalfa	5 (0.4%)	5300 (0.1%)	1 (0.1%)	1000 (0.03%)	4 (1%)	4300 (0.2%)
Other ag. fields	3 (0.2%)	65,600 (1%)	1 (0.1%)	65,000 (2%)	2 (0.4%)	600 (0.03%)
Trees/Orchards						
Willows	26 (2%)	70,984 (1%)	23 (3%)	51,079 (2%)	3 (1%)	19,905 (1%)
Riparian trees	4 (0.3%)	8050 (0.2%)	0 (0%)	0 (0%)	4 (1%)	8050 (0.3%)
Tamarisk	2 (0.2%)	2787 (0.1%)	2 (0.3%)	2787 (0.1%)	0 (0%)	0 (0%)
Other trees/orchards	10 (1%)	12,948 (0.2%)	2 (0.3%)	2200 (0.1%)	8 (2%)	10,748 (1%)
Shrubs and herbs						
Giant reed	5 (0.4%)	5651 (0.1%)	2 (0.3%)	3900 (0.1%)	3 (1%)	1751 (0.1%)
Atriplex or salt bush	7 (1%)	6536 (0.1%)	7 (1%)	4536 (0.2%)	0 (0%)	2000 (0.1%)
Other shrubs/herbs	1 (1%)	47,565 (1%)	0 (0%)	0 (0%)	1 (0.2%)	47,565 (2%)
Other habitats						
Marsh	1 (0.1%)	1050 (0.02%)	0 (0%)	0 (0%)	1 (0.2%)	1050 (0.04%)
Wildflower field	1 (0.1%)	450 (0.01%)	0 (0%)	0 (0%)	1 (0.2%)	450 (0.02%)

Graves et al. (2013) documented that since 1980 the majority of nesting birds were recorded in upland nesting substrate types, 29% of breeding birds were recorded in cattails, 21% in triticale, 13% in Himalayan blackberry, 7% were in unknown habitat types, 5% in bulrush, 5% in prickly lettuce (*Lactuca serriola*), 4% in wheat, 4% in thistle, 3% in mustard, 3% in willows, 1% in stinging nettles, 1% in saltbush, and <1% in alfalfa, barley, giant reed, citrus groves, rice paddy, tamarisk, and wild rose. (*See also* Cook and Toft 2005.) Average colony sizes declined for all habitat types except for colonies in native stinging nettles, although nettles did not support large number of either breeding or non-breeding Tricolors. Mean colony size in cattails was 34%

larger in the early years of records as compared to those in blackberry, bulrush, and thistle, but declined 38% more rapidly than in those other substrates (Graves et al. 2013:6).

The proximity of breeding sites to nearby quality foraging areas is an important determinant of whether a colony will settle in an area for nesting, as described in “Diet and Foraging Ecology” section above.

Another important indicator of breeding-site selection for Tricolor colonies is the presence of young, rapidly and vigorously growing nesting substrates such as cattails, bulrush, and milk thistle (Meese 2007). The plants must be strong enough to support nests for the duration of the breeding period. Thus, not just any spiny or thorny substrate will provide suitable breeding habitat.

The number of birds or colonies nesting in a particular substrate is an important indicator of the value of that habitat, but even more insightful is the reproductive success in different habitat types. Both Cook and Toft (2005) and Meese (2013) reported on reproduction of Tricolored Blackbirds in different nesting substrates using multiple years of data. Cook and Toft (2005) found mean number of chicks per nest varied among nesting substrates, with nests in non-native vegetation fledging significantly more offspring than those in native vegetation. Table 3 below (from Cook and Toft 2005:82) shows mean reproductive success (number of chicks per nest at 8 days after first egg hatched) of colonies by substrate and study region from 1992–2003.

Table 3: Reproductive Success of Tricolored Blackbirds by Nesting Substrate

	Number of chicks per nest		
	n	Mean	SE
Nesting Substrate			
Emergent marsh	40	0.5	0.09
Himalayan blackberry	23	2.0	0.16
Silage – all	26	0.2	0.08
Silage [a]	4	1.0	0.26
Other flooded plants	6	1.2	0.51
Other upland plants	7	1.2	0.37
Total native plants	46	0.6	0.11
Total non-native plants [a]	34	1.7	0.15

[a] *Excluding colonies that were lost to crop harvesting.*

Tricolors nesting in Himalayan blackberry had greater reproductive success than those nesting in grain silage, but colonies in grain silage were far larger than those in any other upland nesting substrate, and where nests were not destroyed by silage harvest, number of fledglings per nest was higher than in native marsh habitat (Table 3; Cook and Toft 2005). These results suggest that the annual loss of nests due to harvest of grain silage during the Tricolor breeding season is a significant factor contributing to the decline of the species.

Meese (2013) documented reproductive success of 870,000 nests from 11 colonies over a 6-year period from 2006 to 2011. He found that only 11% of colonies studied fledged an average of one or more young per nest, revealing chronically low (below-average from previous studies) reproductive success throughout the Central Valley. Importantly, the abundance of insects was positively correlated with reproductive success. The colony with the highest reproductive success of 1.44 fledglings per nest was in milk thistle in Merced County in 2010, surrounded by open rangeland where grasshoppers were super-abundant.

Suitable Tricolor habitat therefore can be more than meets the human eye: factors such as insect availability in proximity to nest sites, age of vegetation, or other currently unknown habitat characteristics provide crucial breeding requirements for Tricolors in addition to suitable nesting substrates (Meese 2013). While many colonies are found in the same location year after year, colonies often move, nesting a second time in one breeding season in a different location, and in different locations in subsequent years. Therefore, it is critical at present to protect the habitat that is <u>documented</u> to be used by Tricolors (each year or occasionally), rather than assuming that protecting habitat that superficially appears suitable but is not actually used (i.e., relying solely on currently protected public lands that do not at present support breeding Tricolors) will be sufficient to conserve the species.

6.0 Factors Affecting the Ability to Survive and Reproduce

Under the California ESA, a petition must include information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce (*see supra*). The petition must also include information about the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, the availability and sources of information, information regarding the kind of habitat necessary for species survival, and a detailed distribution map, all of which are both satisfied below. Cal. Fish & Game Code § 2072.3.

Cited reasons for decline of Tricolors include historical and ongoing loss of suitable breeding and foraging habitats, direct destruction of nests from agricultural harvesting during breeding season, historical market hunting of blackbirds, extensive predation of entire colonies by rats, egrets, herons, coyotes, and other species, poisonings and shootings to protect crops from blackbirds, pesticide use, and an ongoing failure of existing regulatory mechanisms to prevent such threats despite awareness of population declines for decades.

6.1. Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The greatest threats to this species are the direct loss and degradation of habitat from human activities (Beedy and Hamilton 1999). Most native habitats that once supported nesting and foraging Tricolored Blackbirds in the Central Valley have been replaced by urbanization and agricultural croplands unsuited to their needs. In Sacramento County, a historical breeding center of this species, the conversion of grassland and pastures to vineyards expanded from 3,050 hectares in 1996 to 5,330 hectares in 1998 (DeHaven 2000) to 6,762 hectares in 2003 (Calif. Agri. Statistics Serv., www.nass.usda.gov/ca/). Conversions of pastures and grasslands to vineyards in Sacramento County and elsewhere in the species' range in the Central Valley have resulted in the recent loss of several large colonies and the elimination of extensive areas of suitable foraging habitat for this species (Cook 1996, DeHaven 2000, Hamilton 2004, Cook and Toft 2005).

DeHaven et al. (1975) pointed out that many marshes and other "apparently suitable" nesting sites were unused by Tricolors each year. Graves et al. (2013) documented a decline of breeding populations in the Sacramento Valley including both a reduction in average colony size and the total breeding population, and hence the number of sites occupied, from 1907 until 2009. These colonies declined in average size despite the fact that many of the marsh (cattail and bulrush/tule) sites in this region were in wildlife refuges and protected from modification. Increased management for wintering waterfowl may have altered the marshes from their historical conditions, or something other than absolute amount of breeding substrate may be affecting breeding populations, such as insect abundances in foraging habitat (e.g., Meese 2013). The 2014 census documented a resurgence of breeding Tricolors in Sacramento County, which supported 20% of the population, but the overall population for the entire species was so low that this only amounted to fewer than 30,000 birds (Meese 2014). In another example, the coastal population of Tricolors declined 91% in 6 of the last years, yet there has been no direct loss of nests due to agricultural harvests, again suggesting other unknown factors such as lack of sufficient insect prey base to support successful reproduction,

6.1.1 Destruction of Native Habitats

Destruction of Tricolor breeding habitat has been documented as far back as the first published population studies on the species. Neff (1937) stated "...the destruction of nesting habitats by man is of most importance. Reclamation and drainage have destroyed many favorable habitats. Areas in the vicinity of San Francisco and Los Angeles are now so highly developed that it is doubtful whether or not any colonies could exist there. Other habitats have been destroyed by the dredging or cleaning of reservoirs, marshes, and canals in order to destroy the growths of cattails and tules." The surveyors documented specific instances of destruction of known colony sites, including draining and burning of some surveyed localities.

DeHaven et al. (1975) also noted the loss of breeding habitat leading to the loss of colonies where they formerly occurred. Colonies studied near Davis in Yolo County during the 1960s were not located again due to the near-complete loss of nesting habitat. No nesting habitat was found near Riego Road in Sacramento County where Orians (1961a) found colonies, and at Cache Creek in Kern County where Collier (1963) found colonies.

The vast majority of the native habitat for Tricolors has been lost or degraded. Only 560,500 of an original 4,000,000 acres (about 14%) of wetlands in the Central Valley were extant in 1939 (Beedy and Hamilton 1997). By the mid-1980s, an estimated 480,000 acres of freshwater emergent marshes, or 85% of the total remaining freshwater wetlands in 1939, were reduced by one-half to about 243,000 acres (Beedy and Hamilton 1997). Graves et al. (2013) found declines in sizes of colonies in the Central Coast resulted from four early records, and three of these came from cattails in which declines were rapid: remaining marsh nesting habitat has been reduced to small isolated patches of habitat that also support high densities of Tricolor predators. Further, native perennial grasslands—prime Tricolor foraging habitat—have been reduced by more than 99% in the Central Valley and surrounding foothills (Beedy and Hamilton 1997).

6.1.2 Colony Destruction by Agricultural Activities

The relatively recent phenomenon of Tricolors nesting in grain silage fields at dairies was not mentioned by DeHaven et al. (1975) (but see Collier 1968), however silage is well-documented as a primary attribute of present-day Tricolor nest site selection (Beedy and Hamilton 1997, Beedy and Hamilton 1999, Cook and Toft 2005, Meese 2007, 2008, 2009a, 2011). Harvest of grain silage is conducted in relation to moisture content of the forage, the timing of which coincides with Tricolors using the crops for nesting (USFWS 2000). This causes nest destruction and direct mortality, which in turn is threatening much of the remaining breeding population of the species (USFWS 2000). In addition, many former agricultural areas within the range of the Tricolor are now being urbanized, and the trend is projected to continue (Beedy and Hamilton 1997).

Dairy grain silage consists of varieties of wheat, often triticale, but also barley, oats, and other crops. Crops can be monocultures or mixtures of grain plants and may also be infested with weeds such as prickly lettuce (*Lactuca serriola*) and thistles (*Cirsium* spp.). These plants may grow to 3–4 feet in height and appear to provide some protection against predators on Tricolor nests because of their dense growth, somewhat spiny/irritating character, and typically monotonous relief in the landscape.

Silage fields around dairies are probably highly attractive to breeding Tricolors because of relative protection from predators but also because crops at a single location may cover tens of acres or more. Because they are intensely colonial, tens of thousands of Tricolors can potentially occupy a silage field as small as 20–40 acres in size. Nest densities in these fields are often not as great as in some other upland substrates but approximately one nest per square meter is not uncommon (Liz Cook, pers. comm.). In addition to providing a suitable nesting substrate, dairies typically provide abundant grain sources at their feedlots for settling adult Tricolors, large amounts of nearby foraging habitat for insects (e.g. alfalfa), and reliable water supplies.

Silage is grown to be an early cut green feed. Crops are planted in late winter/early spring and mature to harvest stage usually between about mid-April and the first week in May. Harvest stage occurs when the plants contain the highest amount of moisture in their seed heads (milk stage). This stage may last about a week within which time the plants are most valuable as silage feed. The crop is chopped, often in a single day, into fine pieces and allowed to ferment into the final product that is fed to dairy cows. Fields that grew silage are almost immediately turned over to a second crop such as corn (Liz Cook pers. comm. with David Hardt, refuge manager, Kern National Wildlife Refuge).

Tricolors begin establishing nesting colonies in grain silage in late March/April when the plants are tall and sturdy enough to support nests. This means that the timing of silage harvest usually coincides closely with the late nestling/early fledgling stage of Tricolor offspring. The timing of silage harvest and the Tricolor nesting cycle is such that colonies in silage are always lost unless there is intervention on their behalf or for some other unlikely reason that the crop is not harvested (Liz Cook, pers. comm.).

The concentration of most of the Tricolor reproductive effort into a few large colonies that are selecting grain silage as a nesting substrate has greatly increased the risk of extinction should the annual destruction of such a large proportion of nests continue unabated (Cook and Toft 2005). In 2014, Meese (2014) reported 38% of all nesting substrate was in silage (triticale) although data are not available as to how many colonies or individual birds were lost to harvest during that year. This underscores the heavy reliance on this nesting substrate by these imperiled birds concurrent to the decimation of other suitable breeding habitats such as vast areas of cattail marshes that occurred earlier in the 20th century.

Table 4 below provides examples of breeding failures because of harvest of grain silage from 1993 to 2011. For example, approximately half of the documented Tricolor population in 2000 nested in two silage fields in 2003, and the vast majority of this breeding effort was destroyed. In 2008, 45% of all nests in silage were destroyed, amounting to 140,000 nests in Tulare, Madera, Merced, and Fresno counties. As late as 2011—seven years after the formation of the Tricolored Blackbird Working Group and two years after the updated *Conservation Plan for the Tricolored Blackbird* was published—56% of all nests in silage were still destroyed by harvest. Meese (pers. comm.) reported more colonies lost to harvest in both 2013 and 2014 despite efforts to financially compensate landowners to prevent or delay harvest. Hundreds of thousands of additional nests would certainly have been lost over the years without the concerted effort of a handful of dedicated individuals, who monitored Tricolor colonies and attempted to coordinate buy-outs or harvest delays of the biggest colonies. From 1993 to 2011, more than one million nests were documented to have been destroyed by harvest and certainly many more undocumented nests have been obliterated over the years on private lands.[3] Sources for Table 4 below include Hamilton 1993, Hamilton et al. 1995, Beedy and Hamilton 1997, Hamilton et al. 1999, Hamilton 2000, Hamilton and Meese 2005, Meese 2006, 2007, 2008, 2009a, 2011, and Liz Cook unpublished data. This is not a complete summary of all colonies that nested in silage, only a sample of monitored sites.

[3] There were likely tens if not hundreds of thousands of nests destroyed by harvest over the years for which there is no data due to their locations on private property.

Table 4: Tricolor Blackbirds Breeding in Silage by County, Estimated Number of Nests Saved by Crop Buy-out or Harvest Delay, and Estimated Number of Nests Destroyed

Year	County	Number of Breeding Birds	Number Saved by Buy-out or Harvest Delay	Estimated Nests Destroyed)
1993	Tulare	48,000		48,000
1994	Fresno	70,000		70,000
1994	Kern	11,600		11,600
1994	Tulare	50,000		50,000
1995	Fresno	50,000		50,000
1995	Tulare	50,000		50,000
1996	Fresno	50,000		50,000
1996	Tulare	50,000		50,000
1997	Fresno	52,500		52,500
1997	Tulare	40,000		40,000
1998	Fresno	40,000		40,000
1998	Tulare	40,000		40,000
1999	Tulare	14,000		14,000
2003	Tulare	20,000		20,000
2003	Kern	50,000	20,000	30,000
2006	Kern	158,000	138,000	20,000
2006	Tulare	76,000		76,000
2006	Merced	110,824	70,824	40,000
2007	Tulare	122,870		106,750
2008	Tulare	140,000	110,000	30,000
2008	Madera	10,000		10,000
2008	Merced	55,000		55,000
2008	Fresno	45,000		45,000
2008	Kern	60,000	60,000	0
2009	Merced	20,000		20,000
2009	Fresno	35,000		Unknown
2009	Madera	15,000		Unknown
2009	Kern	18,000	18,000	0
2009	Tulare	144,000	31,500	Unknown
2011	Kern	50,000		30,000
2011	Fresno	20,000		20,000
2013	Riverside	2000		1330
TOTAL				**≥1,000,000**

Prior to 1980, the Sacramento Valley held the largest number of birds, whereas from 1980 onwards the San Joaquin Valley supported the largest total breeding populations of Tricolored

Blackbirds (Graves et al. 2013). Graves et al. (2013) postulated one reason for the decline in average colony size in the San Joaquin Valley and decline in total breeding population was that colonies in triticale were all within the San Joaquin Valley (or Sacramento County), all during the last 20 years, and they were >40 times larger than colonies in other habitats during this period. These are the very colonies that were often destroyed.

Other agricultural activities such as sheep grazing can destroy Tricolor colonies. At Owens Creek in Merced County in 2010, a colony of 15,000 birds nesting in milk thistle and mustard produced only 1,500 fledglings after intensive grazing of the vegetation by domestic sheep (Meese 2010).

6.1.3 Destruction of Other Suitable Upland Breeding Substrates and Surrounding Habitats

Cook and Toft (2005) found Himalayan blackberry supported the highest densities of nesting Tricolors among all used substrates and reproductive success was significantly higher in these than other most commonly used substrates (emergent marsh and silage) using data from 1992 to 2003 (Table 4). However, Himalayan blackberry nesting sites are currently not protected and many important traditionally used sites have been lost in recent years (Cook and Toft 2005).

Other important upland nesting substrates, including thistles and prickly lettuce, are likewise not protected because they are considered to be non-native plants and often occur on private property. For example, the 2010 Owens Creek colony in milk thistle and mustard described above was destroyed by grazing sheep. In Merced County in 2011, two large colonies were reported in milk thistle: Owens Creek with 20,000 birds and South of Childs with 10,000 birds: both of these colonies were entirely destroyed by cutting of the thistle (Meese 2011). That same year, Meese (2011:12) also noted that at least four colony sites in Himalayan blackberry substrates on private property were all apparently sprayed with herbicides since 2010. These included Hulen Levee in Merced County, Central American 1 in Stanislaus County, Openshaw Road in Butte County, and Ostrom Road in Yuba County. A colony of 50,000 Tricolors at Sandy Mush and 99 in Merced County in 2011 was reduced to just 15,000 due to harvest of the fava bean crop in which they were nesting.

6.2 Inadequacy of Existing Regulatory Mechanisms

The Tricolored Blackbird is not protected by existing regulatory mechanisms. The Yolo Audubon Society submitted a petition to the Commission to list this species as endangered under the state Endangered Species Act in 1991, but the petition was withdrawn in 1992 (Beedy and Hamilton 1997:19-20). Based on concerns about the Tricolor's population status, FWS included this species as a Category 2 candidate for federal listing as either threatened or endangered. *See, e.g.*, 59 Fed. Reg. 58992 (November 15, 1994).[4] However, FWS later decided to discontinue the

[4] Category 2 candidates are species for which information in the possession of FWS indicates that proposing to list as endangered or threatened is possibly appropriate, but for which persuasive data on biological vulnerability and threat are not currently available to support proposed rules.

practice of maintaining a list of Category 2 candidates. 61 Fed.Reg. 64,481 (December 5, 1996). The Center for Biological Diversity submitted a petition to emergency list the species as endangered under the state and federal Endangered Species Acts in 2004, but this was denied.

Currently, the Tricolored Blackbird is only considered a FWS non-game bird of management concern (species are of concern because of (1) documented or apparent population declines, (2) small or restricted populations, or (3) dependence on restricted or vulnerable habitats) and a species of special concern by CDFW (animals not listed under the federal Endangered Species Act or the California Endangered Species Act, but which nonetheless (1) are declining at a rate that could result in listing, or (2) historically occurred in low numbers and known threats to their persistence currently exist). These designations do not provide any specific legal protection to the bird aside from the requirement that project's triggering CEQA review must analyze the impacts of the proposed action on the Tricolor. *See, e.g.*, 14 Cal. Code Regs.§§ 15065, 15380. However, its special status does not protect the species from activities that do not trigger CEQA review. Furthermore, while the nests and eggs of this species are protected under the California Fish & Game Code § 3503 *see supra*, CDFW has failed to enforce the law to end the devastating annual "take" by private property owners during Tricolor nesting season.

6.3 Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Neff (1942) reported that:

> "Market hunting of blackbirds in the interior valleys of California became a thriving business in about 1928 or 1929, and a dependable market for them was developed largely through Italian produce firms in the larger cities. During the depression years the number of men so engaged increased markedly, but decreased by 1936 or 1937. Using automatic shotguns and firing into dense masses of blackbirds feeding on rice stubble, these market hunters killed large numbers of all species of blackbirds; one group of market hunters shipped nearly 400,000 dressed blackbirds from one Sacramento Valley shipping point in five seasons, and during the winter season of 1935-1936 they shipped about 88,000 birds."

6.4 Disease or Predation

Historical accounts documented the destruction of nesting colonies by a diversity of avian, mammalian, and reptilian predators (Beedy and Hamilton 1999). Historically, terrestrial predators have probably included wolves (*Canis lupus*), coyotes (*Canis latrans*), gray foxes (*Urocyon cinereoargenteus*), raccoons (*Procyon lotor*), mink (*Mustela vison*), striped skunks (*Mephitis mephitus*) and spotted skunks (*Spilogale gracilis*), gopher snakes (*Pituophis catenifer*), non-native rats (*Ratus ratus*), western rattlesnakes (*Crotalus viridis*), and king snakes (*Lampropeltis getulus*). Avian predators are reported to be Black-crowned Night-Herons (*Nycticorax nycticorax*), Great Blue Herons (*Ardea herodias*), Common Ravens (*Corvus corax*), Cooper's Hawks (*Accipter cooperii*), Burrowing Owls (*Athene cunicularia*), American Crows (*Corvus brachyrhynchos*), Swainson's Hawks (*Buteo swainsoni*), Northern Harriers (*Circus* *cyaneus*), Barn Owls (*Tyto alba*), Short-eared Owls (*Asio flammeus*), Yellow-billed Magpies *(Pica nuttalli*), and Merlins (*Falco columbarius*). Predation by feral cats (*Felis catus*; Beedy and Hamilton 1997), rats (*Rattus* spp.; Meese 2010) and Cattle Egrets (*Bubulcus ibis*; Meese 2013), has recently been reported. Tricolors respond to predators by sitting silently rather than attempting to attack them, as do Red-wings (Beedy and Hamilton 1997, 1999).

Predation is a major cause of large-scale nesting failures in many Tricolor colonies, especially those nesting in native emergent marshes (Hamilton et al. 1995, Beedy and Hamilton 1997; Hamilton 2000). Cook and Toft (2005) found that reproductive success was significantly lower in native emergent marshes than other substrates, excluding silage that was not lost to harvesting operations (Table 3). Heron and raccoon predation upon colonies nesting in marshes, especially, can destroy all or nearly all nests within colonies (Hamilton et al. 1995, Hamilton 2000). For example, Tricolor nesting at Kern NWR, Kern County and at Maxwell I and Maxwell II colonies in Colusa County failed due to night-heron predation. Black-crowned Night Heron predation—which often results in the nest failure of an entire colony —is particularly troubling at national wildlife refuges, which are becoming increasingly important nesting sites for both Night Herons and Tricolors as private range and dairy lands are converted to vineyards and orchards or urban uses, and as grain silage fields are subject to harvest during nesting season. Some large colonies (up to 100,000 adults) may lose >50% of nests to coyotes (*Canis latrans*), especially in silage fields, but also in freshwater marshes when water is withdrawn (Hamilton et al. 1995). Thus, water management by humans often has the effect of increasing predator access to active colonies (Shuford and Garaldi 2008).

Nesting over water provides some protection from predators (Weintraub and George 2012), but the reduction of native wetlands to less than 4% of their original extent has probably concentrated predator populations in the remaining wetlands more than was true historically (Cook and Toft 2005). As noted above, water management in some areas results in reduced water, and because cattails do not have armaments such as thorns or stinging hairs, nesting blackbirds are exposed to higher rates of predation (Meese 2013). Cook and Toft (2005) found that from 1992 to 2003, a larger proportion of colonies in native wetlands than in upland substrates suffered complete reproductive failure attributable primarily to predation. In particular, some of the largest breeding colonies in wetlands, such as those in the Sacramento Valley, failed completely despite the fact that colonial nesting is considered an adaptation against predation.

More recent studies have documented wholesale reproductive failure of entire colonies due to predation by Cattle Egrets (Meese 2013). Since 2006, predation by Cattle Egrets on eggs and nestlings has caused nearly complete reproductive failures of even very large colonies, but this currently is limited to Tulare County. In contrast to Cook and Toft (2005) which found a correlation between nesting substrate and reproductive success, Meese (2013) documented widespread reproductive failures of entire colonies from 2006 to 2011 that appeared unrelated to nesting substrate. Instead, Meese found that insect abundance around these colonies was insufficient to support successful breeding, resulting in nestling starvation and failure of females to lay eggs. Meese (2014:110) states "[t]his loss of foraging habitat may result in a decline in productivity over a period of years that is difficult to detect, but that decline may ultimately lead to the situation where, despite the availability of suitable nesting substrate, tricolors abandon colonies or decline to extinction in an area where they formerly were abundant." If this is correct, then colonies adjacent to dairies, which recently represent the largest colonies of breeding Tricolors, may appear to be ecological traps, fledging relatively few young in most years even when not lost to silage harvest (Meese 2013).

Cook and Toft (2005) note that in earlier studies, colony settlement was reported to be sporadic and unpredictable (Neff 1937, Orians 1961) and banded nestlings were only somewhat philopatric (DeHaven et al. 1975b). More recent data, however, indicate repeated settlement of many sites despite poor breeding outcomes. The recent losses of known breeding sites were concomitant with the decline in local breeding populations despite an abundance of what appear to be other suitable sites which do not become used. This trend toward apparent increased philopatry probably reflects the now extremely limited availability of suitable nesting habitat.

6.5 Other Natural or Anthropogenic Factors

6.5.1 Storms and Droughts

Severe storms are documented to cause near-complete reproductive failures of colonies. At the Plumas Arboga colony in Yuba County in 2009, a colony of 20,000 Tricolors nesting in cattails produced fewer than 1,000 fledglings after a severe storm (Meese 2009a). Colony monitoring in 2010 reported hundreds of dead nestlings found on the ground beneath nests in milk thistle at the 2,000-bird colony on San Felipe Ranch in Merced County after a severe storm; this colony ultimately produced only 200 young (Meese 2010). Also during 2010 a second colony of 10,000 birds nesting in mustard and milk thistle at Merced NWR was destroyed by storm, with only 500 fledglings produced.

Meese (2010:11) wrote: "[s]pring storms, and especially the winds associated with storms, played a major role in limiting the productivity of several colonies in 2010, especially those established in milk thistle in Merced County. The second settlement at Merced National Wildlife Refuge Duck Slough appeared to be nearly wiped out due to a storm with high winds on May 20, affecting a colony visually estimated to consist of 15,000 breeding birds. The nearby San Felipe Ranch colony was affected by the same storm, and when surveyed on May 27 was visually estimated to have suffered a greater than 50% mortality of nestlings, as hundreds of dead nestlings were observed on the ground beneath the milk thistle nesting substrate. The Bear Creek colony, also established in milk thistle, was not as severely impacted but hundreds of nests were observed to have been affected, most apparently shaken sideways during strong winds. The eggs in these nests were likely spilled out on to the ground while the nestlings were either ejected or forced to cling precariously to horizontal nest cups."

Drought also may have adverse effects on Tricolored Blackbird populations, but no empirical data are available (Bob Meese, pers. comm.) Beedy (2014:3) wrote that "the recent drought and effects of climate change have noticeably reduced the extent of suitable nesting and foraging habitat in the Central Valley compared to conditions when I first began my intensive studies of this species in the mid-1980s. The effects of the drought on the available wetlands and moist, insect-producing agricultural fields, was especially apparent during this year's Statewide Survey—in the third year of a severe drought." However, the Tricolored Blackbird population had been steadily declining from 2008 to 2014, so drought cannot be implicated in the decline for the entire time period.

The Tricolored Blackbird evolved over millennia in a region (California) that is naturally susceptible to periodic drought and severe storms. However, their population size and available habitat has been so reduced by humans over the past century that natural weather events now have a more pronounced effect on the overall population—this is precisely the problem when small, endangered populations with little remaining habitat are faced with large-scale natural stochastic (unpredictable) events such as droughts and severe storms. Drought and severe storms may have adverse effects on reproductive success, but this only makes protecting active nesting colonies from damaging human activities such as harvest, pesticides, grazing sheep, or poor water management all the more critical.

6.5.2 Poisons and Contaminants

Various poisons and contaminants have caused mass mortality of Tricolored Blackbirds (Shuford and Garaldi 2008). McCabe (1932) described the strychnine poisoning of 30,000 breeding adults as part of an agricultural experiment. Neff (1942) considered poisoning to regulate numbers of blackbirds preying upon crops (especially rice) to be a major source of mortality. This practice continued until the 1960s, and thousands of Tricolored Blackbirds and other blackbirds were exterminated to control damage to rice crops in the Central Valley.

Beedy and Hayworth (1992) observed a complete nesting failure of a large colony (about 47,000 breeding adults) at Kesterson Reservoir, Merced County, and selenium toxicosis was diagnosed as the primary cause of death. Hosea (1986) attributed the loss of at least two colonies to aerial herbicide applications.

Beedy and Hamilton (1997) documented more evidence of Tricolor mortality due to contaminants. A large Tricolor breeding colony of nearly 50,000 birds at Kesterson Reservoir in Merced County experienced a complete nesting failure in 1986 (Beedy and Hayworth 1992). Some of the dead nestlings had club feet; other shorebirds and water birds collected at the reservoir had similar deformities. Pathological examinations of the Tricolor nestlings indicated heart muscle degeneration, and liver sampled showed higher concentrations of selenium than in Red-wing nestlings collected in an uncontaminated area at Merced NWR (Beedy and Hayworth 1992). The cause of the 1986 Tricolor nestling deaths was suspected to be selenium toxicosis (Beedy and Hamilton 1997). A recent incident reported to CDFW was the death of Tricolors from in Riverside County that were poisoned by bait left out for ground squirrels (R. Cook, pers. comm.).

Hamilton observed a colony sprayed by mosquito abatement operators in Kern County, and all sprayed eggs failed to hatch, and the loss of at least two Tricolor colonies was attributed to herbicide applications (Beedy and Hamilton 1999). While the link between environmental contaminants and nesting failure of Tricolors is largely unstudied, enormous amounts of chemicals are introduced into the environment every year by the California agriculture industry, particularly in the Central Valley, which is the historical stronghold of the Tricolor and the most intensive agricultural region in the state. Table 5 shows amount and type of pesticides applied in five of the counties that support the some of the greatest numbers of breeding Tricolors.

Table 5. Type and Amount of Pesticides Used in Fresno, Merced, Sacramento, San Joaquin, and Tulare Counties (California Department of Pesticide Regulation 2002)

County	Chemical	Pounds Applied	Chemical	Pounds Applied
Fresno	Aluminum Phosphide	15,080.9830	Metam-Sodium	1,981,875.2816
	Bacillus Thuringiensis I	1,690.3241	Methoprene	15.6594
	Chlorophacinone	0.1511	Methyl Bromide	417,510.3194
	Chlorpyrifos	321,888.9509	Oryzalin	11,850.1164
	Copper Sulfate	115,084.1100	Petroleum Oil	2,329,338.9000
	Diazinon	70,289.4242	Phosmet	95,969.6584
	Diphacinone	0.7339	Pyrethrins	162.6464
	Malathion	43,158.9558	Strychnine	40.7266
	Mancozeb	37,528.9088	Zinc Phosphide	35.7129
Merced	Aluminum Phosphide	2,971.6662	Metam-Sodium	422,398.3113
	Bacillus Thuringiensis I		Methoprene	157.8358
	Chlorophacinone	1.1929	Methyl Bromide	131,116.9563
	Chlorpyrifos	61,795.4767	Oryzalin	2,594.6929
	Copper Sulfate	105,569.4900	Petroleum Oil	569,390.7400
	Diazinon	23,995.9920	Phosmet	9,044.3520
	Diphacinone	0.8929	Pyrethrins	590.9544
	Malathion	17,868.8865	Strychnine	89.1223
	Mancozeb	8,991.6591	Zinc Phosphide	265.5314
Sacramento	Aluminum Phosphide	1,957.8636	Metam-Sodium	34,853.1512
	Bacillus Thuringiensis I	77.9603	Methoprene	278.8712
	Chlorophacinone	0.1346	Methyl Bromide	9,339.2350
	Chlorpyrifos	29,307.3649	Oryzalin	6,544.5375
	Copper Sulfate	49,294.402	Petroleum Oil	223,652.1400
	Diazinon	14,780.1577	Phosmet	8,031.6110
	Diphacinone	0.3048	Pyrethrins	71.4711
	Malathion	2,852.0994	Strychnine	0.8122
	Mancozeb	11,154.9237	Zinc Phosphide	60.1408
San Joaquin	Aluminum Phosphide	2,362.2914	Metam-Sodium	10,122.7993
	Bacillus Thuringiensis I	562.7223	Methoprene	95.2427
	Chlorophacinone	0.1439	Methyl Bromide	176,519.4093
	Chlorpyrifos	52,076.1370	Oryzalin	6,757.1516
	Copper Sulfate	100,613.6600	Petroleum Oil	534,153.4400

	Diazinon	17,664.0315	Phosmet	10,195.7060
	Diphacinone	0.3140	Pyrethrins	260.5963
	Malathion	11,265.6954	Strychnine	35.1823
	Mancozeb	23,385.1615	Zinc Phosphide	12.6028
Tulare	Aluminum Phosphide	2,786.4064	Metam-Sodium	117,861.9303
	Bacillus Thuringiensis I	198.8293	Methoprene	0.6954
	Chlorophacinone	0.2265	Methyl Bromide	123,817.5579
	Chlorpyrifos	202,428.6137	Oryzalin	6,219.4719
	Copper Sulfate	267,978.4700	Petroleum Oil	2,978,688.3000
	Diazinon	43,560.2082	Phosmet	81,260.5161
	Diphacinone	1.1976	Pyrethrins	46.7505
	Malathion	25,292.3724	Strychnine	57.4777
	Mancozeb	16,267.6174	Zinc Phosphide	1.6000

While Tricolors were not studied directly, many of the chemicals used within the breeding range of the Tricolor are known to be highly toxic to birds. For example, malathion, chylorpyrifos, and diazinon are organophosphorus pesticides that bind with cholinesterase in animals and disrupt neural functioning. Chlorpyrifos is moderately to very highly toxic to birds (EXTOXNET 2004). Birds are quite susceptible to diazinon poisoning: in 1988, the EPA concluded that the use of diazinon in open areas poses a "widespread and continuous hazard" to birds. Bird kills associated with diazinon use have been reported in every area of the country and at all times of the year. Birds are significantly more susceptible to diazinon than other wildlife (EXTOXNET 2004).

Malathion is moderately toxic to birds. The reported acute oral LD50 values are 167 mg/kg in blackbirds and starlings (EXTOXNET 2004). The precise oral or inhalation median lethal doses for aluminum phosphide or phosphine in birds are not known, but exposure of turkeys and hens to 211 and 224 mg/meters cubed for 74 and 59 minutes respectively resulted in labored breathing, swelling of organs, tonic-clonic convulsions and death (EXTOXNET 2004).

Methoprene is slightly toxic to birds, but non-lethal effects that may affect survival of the birds appeared at acute oral doses of 500 mg/kg, and included slowness, reluctance to move, sitting, withdrawal, and incoordination (EXTOXNET 2004). These effects may decrease bird survival by making them temporarily more susceptible to predation (EXTOXNET 2004).

Phosmet is documented to be highly toxic in Red-wings, with a reported acute oral LD50 of 18 mg/kg (EXTOXNET 2004). Zinc phosphide is highly toxic to wild birds, although blackbirds were found to be less sensitive than other taxa (EXTOXNET 2004).

6.5.3 Killing Blackbirds for Crop “Protection”

Historically, blackbirds were reportedly shot in great numbers by ranchers in order to drive the flocks away from crops, or by pleasure hunters utilizing blackbirds for target practice, and poison to regulate blackbird damage to crops was a major source of adult mortality (Neff 1942). Beedy and Hamilton (1997) noted that this practice continued until the 1960s, during which thousands of Tricolors were killed in the Central Valley. Reduction in numbers of blackbirds and improved harvesting methods has resulted in a decrease in blackbird extermination programs in the region, but the practice of shooting blackbirds has not ended. A history of widespread persecution of blackbird species has contributed to the Tricolor population decline documented over the past century, and may account for some of the ongoing population decline.

The killing of blackbirds in autumn in paddies of ripening rice in the Sacramento Valley is a known but unquantified source of mortality to post-breeding adult Tricolored Blackbirds. Due to the similarity in appearance to Red-wings, rice farmers who shoot blackbirds kill both species, and perhaps others (Bob Meese, pers. comm.). As noted by Meese (2009a:16):

> "Colonies in the Sacramento Valley are much less dependent upon ephemeral substrates than are those in the San Joaquin Valley, but Sacramento Valley birds have their own serious threats. This year, two birds that I banded in 2008 were shot by a rice farmer outside Richvale in Butte County and subsequently reported to me by staff at Sacramento National Wildlife Refuge. Although only two Tricolors were confirmed killed, these were apparently turned in to federal wildlife officials because of the bands that were found on their legs and serve to suggest a potentially much larger problem. One wonders how many Tricolors are shot each summer in the Sacramento Valley? Previously, in 2006, I was told by two Colusa County staff that flocks of blackbirds were annually shot in Colusa County and that such shooting did not require a permit. This is true for most blackbird species, but not for Tricolors, which are protected under the Migratory Bird Treaty Act. Additionally, a rice farmer in Yuba County told me in July, 2008 that he knows of several rice farmers who annually "herd" and then shoot blackbirds. The shooting of blackbirds during the breeding and post-breeding seasons is in all probability a source of additive mortality, that is, mortality in addition to that which would normally occur due to other factors (starvation, disease, etc.), as it involves primarily breeding and post-breeding adults, and thus may be especially important as a limiting factor in population growth in Tricolors."

6.5.4 Allee Effect of Small Population Size

As noted above, small populations, especially those that are squeezed into ever-smaller areas of suitable habitat, are more vulnerable to stochastic (unpredictable) events such as storms and droughts. Cook and Toft (2005) also raised an alarm bell about the effects of a small population size to a species with socially facilitated breeding. With these species, reduced populations may become extinct through Allee effects, or "inverse density dependence," defined as a positive relationship between population density and survival and reproduction (Allee 1931, Stephens and Sutherland 1999). Conversely, as population density and colony size decreases, so too does survival and reproduction, even if there may remain several hundred thousand individual birds. The Passenger Pigeon, once the most abundant bird in North America, may have ultimately succumbed to extinction following widespread hunting and habitat loss because it could not survive at low population densities (Stephens and Sutherland 1999).

Cook and Toft (2005:85) stated:

> "Like Passenger Pigeons, Tricolored Blackbirds breed colonially and are now adapted to the patchy distribution of a habitat that was widespread before European immigration to North America. The extinction of the Passenger Pigeon has been attributed to a combination of highly social and nomadic breeding, the fragmentation of the mast forests that provided abundant forage, and intense commercial hunting (Stephans and Southerland 1999). Together these factors pushed the population past a lower threshold of inverse density dependence (the Allee effect) and on to the alternative stable state of global extinction (Stephans and Southerland 1999). Importantly, Passenger Pigeon was once the most abundant bird species in North America, with flocks reported to darken the skies for hours (Wilcove 1999), similar to descriptions of flocks of Tricolored Blackbird in California's Central Valley in the mid-1800s (Heermann 1859)."

Cook and Toft pointed out that because local populations of Tricolored Blackbirds are still found in dense breeding colonies, they can leave a false impression of abundance upon casual observers. The long-term population trends and patterns in reproduction show that the Tricolored Blackbird possesses most of the traits that ultimately led to the extinction of Passenger Pigeon in the same ecological circumstances. These factors include the loss of vast areas of native wetland along with the increasing loss of upland, non-native vegetation favorable for nesting, the trend of decreasing colony size in a highly social breeder, a habit of itinerant breeding (Hamilton 1998), and wholesale slaughtering of the largest breeding colonies in agricultural harvest.

7.0 Degree and Immediacy of Threat And Request for Emergency Action

7.1 Degree and Immediacy of the Threat

The San Joaquin Valley and Sacramento Valley have historically been the heart of the Tricolor's range and supported the largest populations. The recent population decline has been most severe in the San Joaquin Valley and along the Central Coast. The number of birds counted in the San Joaquin Valley plummeted 78% in 6 years, from 340,700 to about 73,500 birds, and the decline in especially alarming in Kern and Merced counties (Meese 2014). Efforts to provide water in private duck clubs adjacent to dairies in Kern and Tulare counties have been largely ineffective at halting the steep decline in the number of breeding birds in Kern County over the past 3 years, to an all-time low (Bob Meese, pers. comm). Along the Central Coast, the number of birds is down 91% in 6 years, from 7,014 to 627 birds. For many years few birds were recorded nesting in their historical stronghold of Sacramento County where once entire colonies of 100,000 birds were observed (Neff 1937); in 2014 fewer than 30,000 total birds were recorded in the County. Active nesting colonies of the extremely imperiled Tricolored Blackbird continue to be destroyed by crop harvest, grazing sheep, pesticide use, and poor water management, all of which have caused failures of entire of nearly entire colonies in recent years (Meese 2007, 2008, 2009a, 2010, 2011). Further, an unknown number of Tricolors are shot and killed each year while foraging in rice paddies in the Sacramento Valley during autumn.

The population in southern California remains highly endangered as well with an average of fewer than 6,000 birds observed during springtime breeding surveys conducted since 2005. Although Meese (2014) reported an increase of 126% in southern California over the 2008 census, as R. Cook (2014) explained: "this magnitude of change cannot be accounted for by local reproduction and recruitment. On closer examination, it is apparent that the increase occurred predominantly in Los Angeles County, and specifically the Mojave Desert area between the San Gabrielle Mountain range and the Kern County border. In 2014, 4,500 birds were reported from Holiday Lake alone versus 840 in all of Los Angeles County in 2011. Holiday Lake is only 45 linear miles from the city of Bakersfield in the southern San Joaquin Valley and only slightly further through the Tehachapi Pass. The number of birds in this area has varied between survey years from approximately 600 to 5,000. However, the data reflect no concomitant changes elsewhere in southern California which suggests that these fluctuations are local and do not impact population dynamics in the rest of southern California. The most plausible explanation for the apparent increase this year and the changes observed in Los Angeles County throughout the life of the surveys is occasional and temporary influx of birds from the Central Valley."

Currently the entire global population of Tricolored Blackbirds counted during surveys is less than half the size of a single colony that was reported in 1934 (Neff 1937, Meese 2014). The travesty is that the dire situation of the Tricolor has been known for the past two decades by state and federal agencies, and despite heroic efforts of several dedicated individuals, the trajectory towards extinction has not been reversed. It is time for immediate regulatory action under the California Endangered Species Act to ensure the conservation of nesting and foraging areas known to be important to Tricolored Blackbirds, to prevent the direct killing of blackbirds at rice paddies, and to provide funding for habitat improvement projects such as those proposed by Lowell Young and the Yosemite Area Audubon Society (see "Recommended Management and Recovery Actions.") If such action is not taken, the Tricolored Blackbird will follow the Passenger Pigeon into the dark abyss of extinction.

7.2 Request for Emergency Action

For the reasons provided above, petitioner requests that the Commission take immediate action on this petition and issue emergency regulations to list the Tricolored Blackbird. The California Fish and Game Code Section 2076.5 permits the Commission to issue emergency listing rules to provide imperiled species with immediate substantive protection. As discussed above, the Tricolor is in immediate need of protection from the severe nesting failures caused each year by agriculture harvesting and plowing activities.

8.0 Impacts of Existing Management Efforts

8.1 Silage Buy-outs and Harvest Delays

The two main grain-field specific conservation actions include silage buy-outs or harvest delays (Meese 2009b). Silage buy-outs involve the payment to landowners of the full market value of the triticale in the portion of the field occupied by nesting Tricolors. Harvest delays are financial compensation to landowners for the reduction in the value of their crop from the delay in its harvest until the young Tricolors have fledged from their nests. Meese (2009b) explains that the key difference between a harvest delay and a silage buy-out is the timing of the harvest of the crop following the fledging of the young Tricolors. In the silage buy-out, the farmer agrees to wait until essentially all birds, including the breeding adults plus the newly fledged young, have departed and are fully independent of the field. In a harvest delay, the farmer agrees to delay the harvest only until the young have fledged (left the nests). Thus, in a harvest delay, the young are still present in the field on the day of harvest, being fed by adults during the day and roosting there at night. This difference may be due to the desire to minimize the impact of the harvest delay on the yield and nutritional quality of the crop.

The practice of buying out farmers or delaying harvest of silage to prevent nest destruction during active breeding undoubtedly has saved hundreds of thousands of birds. From 2005 to 2009, these efforts resulted in the conservation of the breeding efforts of a low of 16% in 2007 to a high of 86% in 2005 of the birds nesting in silage fields, thus contributing to Tricolor productivity (Meese 2009b:5). Over the five years from 2005 to 2009, payments totaling $331,921 were made to conserve 11 breeding colonies consisting of 546,000 birds which subsequently produced 396, 025 young (Meese 2009b:6). However, this practice has not always been reliable and depends upon the volunteer cooperation of the farmer and available funds. As evidenced in Figure 4 below (from Meese 2009b:4), in some years the vast majority of breeding effort was not conserved.

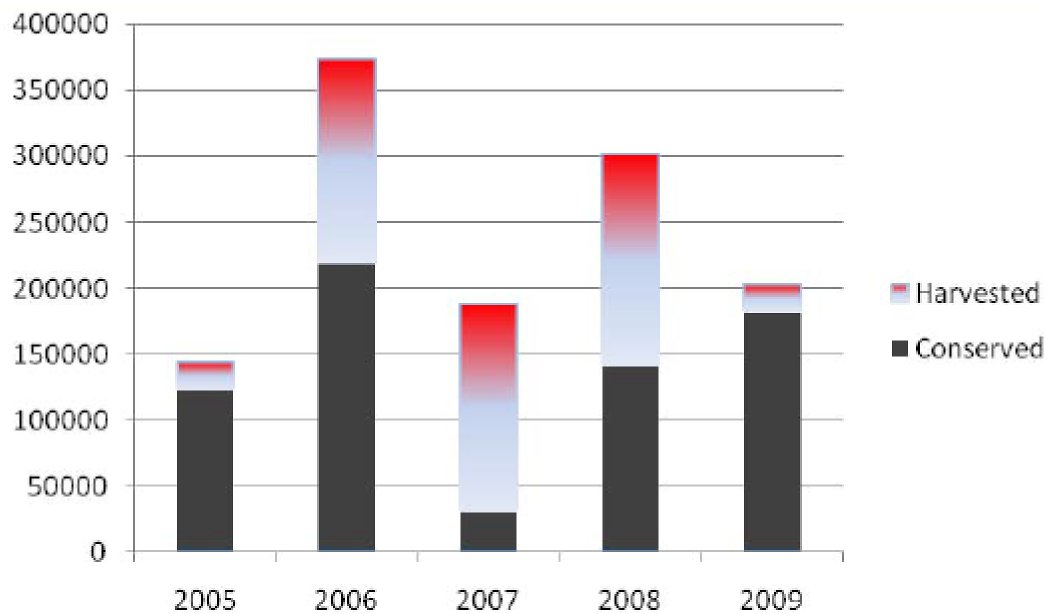

Figure 4: Fates of Tricolored Blackbirds in Silage Fields, 2005 to 2009

Many of the most important recent colonies have been destroyed before it was too late to save them, despite concerted efforts to do so by Tricolor biologists and the FWS. For example, Meese (2006:5-6) noted: "Deer Creek Dairy, Tulare County, was destroyed days after the owner told Scott Frazer, USFWS biologist, that he would not cut the field until after the birds had fledged. This harvest was reported to the Fresno Field Office, Enforcement Division of the USFWS, and harvest was halted by direct intervention by the USFWS officer but not until an estimated 60% of the colony had been harvested, including a single pass through the center of the colony."

In 2011, the year for which the most recent data are available on the Tricolor portal regarding specific colony fates, many instances of nest destruction by crop harvesting were documented, with many colonies destroyed, seemingly willfully:

> "Colonies from Kern County to Merced County were destroyed by harvest or the cutting of the nesting substrate in 2011. The West Poso colony in Kern County was destroyed by harvest just as the young had begun to fledge from their nests. The Producer's Dairy colony in Fresno County was destroyed a week after it was discovered. The owner had preferentially harvested the portion of his triticale field that was occupied by the breeding tricolors as only this portion of this field had been harvested when the site was observed on April 12. The Owens Creek and South of Childs colonies in Merced County were destroyed when the weedy fields in which they were situated were cut. The Sandy Mush and Highway 99 colony, also in Merced County, was cut in half despite on-going conversations with the farmer that sought to conserve the colony through a harvest delay whereby the farmer was to be compensated for his lost revenue that would have resulted from the delay in the harvest of his field of fava beans. Only 10-15,000 birds out of an original colony of 50,000 birds remained after half of the field was harvested." (Meese 2011:12)

Efforts to protect partial colonies have failed to save the nesting effort, even with the cooperation of the farmer, such as this example from 2007: "[n]egotiations between the Service and the landowner, who had prior experience with nesting tricolors and the silage buy-out process, resulted in the signing of a contract to sell the silage occupied by the nesting birds while allowing the farmer to harvest the triticale not occupied. The harvest of the unoccupied triticale proceeded as scheduled, but the day following harvest in excess of 90% of the tricolors deserted the site. The landowner was immediately contacted to inform him of the departure of the birds and to request that the contract be canceled." (Meese 2007:17).

In 2013, four silage colonies were destroyed due to harvest, including the largest colony in southern California in Riverside County. This harvest occurred despite the fact that the landowner had been contacted and an agreement for financial compensation apparently was in its final stages, yet he harvested his field without informing anyone (R. Cook, pers. comm). In 2014, at least two silage colonies were lost to harvest in Merced County, and an additional is suspected (Bob Meese, pers. comm).

Meese (2009b:6) noted that "a permanent solution to the dilemma between the needs of the nesting birds and the needs of the farmers does not consist of annual negotiations between U.S. Fish & Wildlife Service staff and San Joaquin Valley farmers; rather, it consists of the provision of permanent nesting habitats surrounded by productive foraging habitats that provide a secure alternative to nesting in triticale fields (Tricolored Blackbird Working Group 2007). Previous attempts to create such alternative nesting habitats (e.g., ECLA Pond in Kern County, Toledo Pit in Tulare County) have met with limited success, but unless the tricolor modifies its breeding distribution, this is the only realistic resolution to the conflicts. Recent changes including intense predation by cattle egrets (*Bubulcus ibis*) and the loss of formerly productive alfalfa foraging habitats to conversion to orchards and vineyards may be reducing the suitability of the southern San Joaquin Valley to tricolor breeding (Meese 2009a), only complicating future attempts to increase the abundance of the species."

Clearly, however any such voluntary measures to buy-out silage crops or delay harvest over the past decade have not worked. The Tricolor population has declined precipitously despite all efforts to date, and the global population is currently less than half that of a single colony that was reported in 1934 in Glenn County. The species unequivocally warrants immediate listing under the California Endangered Species Acts.

8.2 Tricolored Blackbird Working Group and Conservation Plan

The Tricolored Blackbird Working Group is a voluntary group of state and federal agency biologists, non-governmental organizations, industry representatives, and academic scientists who "share concern for the Tricolored Blackbird and a desire to work cooperatively to help to enhance and sustain the birds and their habitats."

The Tricolored Blackbird Working Group meets twice per year to discuss both long-term, strategic efforts as well as short-term immediate actions necessary to conserve Tricolors. The Working Group (1) assesses the needs for and effectiveness of strategies and efforts that are already implemented, and (2) identifies steps yet to be taken that are necessary to conserve breeding colonies and surrounding foraging habitats. Generally, a spring meeting emphasizes the needs for the upcoming breeding season, while the fall meeting reviews results of the breeding season and sets priorities for next steps. The Working Group crafted the *Conservation Strategy for the Tricolored Blackbird* from 2004 to 2007 (Tricolored Blackbird Working Group 2007), and designed and prepared for distribution a pamphlet describing the Tricolored Blackbird and efforts underway to try to conserve it. Numerous, less formal communications and meetings occur among Working Group members year-round.

The Tricolored Blackbird Working Group includes: Audubon California; California Association of Resource Conservation Districts; California Farm Bureau Federation; California Cattlemen's Association; California Department of Fish and Game; California Department of Food and Agriculture; Central Valley Bird Club; Central Valley Joint Venture; Natural Resources Conservation Service; Pacific Gas and Electric Company; PRBO Conservation Science; Sonoran Joint Venture; Sustainable Conservation; University of California, Agriculture and Natural Resources; Western Riverside County MSHCP; U.S. Fish and Wildlife Service; U.S. Geological Survey; and the Western United Dairymen.

There are a number of scientific efforts underway by agency and non-agency groups that are part of the Tricolored Blackbird Working Group to monitor the population of Tricolored Blackbirds and understand natural and anthropogenic factors correlated to breeding-site selection and reproductive success. These efforts include:

- annual field work to detect and monitor (i.e. document the fates of) the largest colonies in the Central Valley and Southern California to help to prioritize colonies for conservation actions, to estimate the numbers of breeding adults, to estimate the numbers of young produced (i.e. derive an estimate of colony productivity), and to attempt to identify the factors responsible for observed patterns of productivity
- annual banding of primarily adults birds at several breeding colonies to help to document spatial and temporal movements, estimate life history parameters, and to evaluate patterns of site fidelity
- education and outreach, including the production and distribution of a brochure to describe the efforts being made on behalf of the tricolored blackbird and to encourage agency field personnel and birders to report observations of banded birds
- development of the web portal to provide information on the Tricolored Blackbird and to accumulate, document, and disseminate data on colonies and observations of banded birds and aggregations, both breeding and non-breeding.

These scientific efforts have provided a vast literature documenting population size by region, colony locations and fates, and variables correlated with reproductive success and selection of breeding sites. These intensive scientific efforts have provided clear and unequivocal evidence of severe population declines and confirm the significant adverse effects of silage harvest, water management, depredation by rats and Cattle Egrets, and other factors that are implicated in the Tricolor's current predicament.

Science is important but on-the-ground action is needed. However, it is abundantly clear that volunteer efforts to save active nesting colonies have failed in recent years. The *Conservation Plan* was developed in 2007 and updated in 2009, but few conservation efforts to actually improve habitat on the ground have been implemented, and as noted above, numerous efforts to save colonies from silage harvest were shunned by the landowners and the nestlings were brutally mowed down despite funding available to prevent it. Meese (2013) emphasized the importance of high-quality foraging habitats close to nesting colonies that provide abundant insect prey for high reproductive success, but these habitats have continued to be eliminated, which likely led to the chronic very low reproductive success of colonies documented in recent years (Meese 2013). Habitat-improvement efforts including ideas to lure birds to protected high-quality nesting sites have been suggested, but no funding has been provided to support these efforts.

9.0 Recommended Management and Recovery Actions

Meese (2014) provided the following recommendations for management and recovery of the Tricolored Blackbird:

1. Eliminate all known sources of mortality, including the losses of eggs and young via harvest of their nesting substrate and adults in autumn when causing depredations in rice.

2. It is essential to develop a mechanism for conserving at-risk colonies. A mechanism is required that consists of 1) field workers who *detect settlements* of birds in ephemeral nesting substrates (e.g., triticale fields), 2) a person or persons to whom the field worker *reports the presence of birds in ephemeral, at-risk locations* and who has the responsibility of contacting landowners and informing them of the protected status of the birds and of funding available to compensate them, 3) a cooperative extension specialist or other independent expert who *estimates the loss in value* of the crop as a result of the harvest delay, 4) a field worker who *monitors and documents the results* of conservation actions (successful delay until a week past average date of fledging, an estimate of the number of young fledged, a description of the process of harvest in those cases where fledglings are still present in the field when it is being harvested with an emphasis on the effects on the behavior of the fledglings post-harvest). 5) All of these *actions should be documented and then be reported* to a meeting of the Working Group and provided in a report that is posted to the Portal.

3. A legislative fix to eliminate exemption of protection under the MBTA is needed for red-winged blackbirds in California. If red-wings cannot be shot and shooting stops in autumn in rice, this will also save the lives of an unknown number of post-breeding adult tricolors that are shot by “mistake” as tricolors and red-wings are superficially nearly identical in appearance and flock together during autumn.

4. Better document conditions which result in relatively high reproductive success. Examine patterns in RS to determine whether, on a time-averaged basis, there is relatively higher RS in colonies in some geographic regions or that are established in different nesting substrates. Use these insights to make recommendations for management actions.

5. Study the effects of harvest on populations of fledglings in crèches that persist on nesting substrates until moments before they’re harvested to best document effects on birds. In some situations, fledglings persist on the original nesting substrates until moments before the substrates are harvested. Study these colonies and document where the birds go when the harvester shows up and what do they do when they return to the just-harvested field.

6. Take an ‘all hands on deck’ approach to tricolored blackbird conservation that includes representation by all industries that may be affected by a listing and all systems of protected areas, including the National Wildlife Refuge System, State Wildlife Areas, DOD installations, and private preserves.

7. Work with landowners in foothill and other locations with extensive rangelands where the availability of nesting substrate may be limiting reproduction; add nesting substrates where they are lacking, enhance nesting substrates where they are limiting, and protect nesting substrates where necessary. Fund landowners who want to conserve tricolors but who incur a cost in doing so.

8. Provide supplemental insect foods (meal worms, possibly others) to investigate whether supplemental feeding may increase RS.

9. Provide meal worms or other insects to settling birds at desired locations to see whether the supplemental foods may influence breeding site selection.

10. Focus efforts on regions with a recent history of successful reproduction (e.g., Sierra Nevada foothills) and, where appropriate, seek to create additional breeding sites.

11. Expand monitoring and research into regions which have historically been under-studied (central Sierra foothills, coastal locations) and suggest strategies to sustain or increase reproductive output in these regions. Perhaps fund a volunteer effort by reimbursing volunteers for food and mileage costs for monitoring efforts.

12. Encourage and/or provide monetary incentives to farmers to grow alfalfa, sunflowers, and rice within 3 miles of active tricolored blackbird colonies without insecticides or to delay their use until after the young have fledged and left the area.

13. Investigate the relative abundance of insects in rice paddies under organic culture to that in commercial rice paddies to document whether organic rice provides a better foraging substrate than does commercial rice (as has been suggested by relatively high RS at the Conaway Ranch in Yolo County, where both organic and commercial rice is grown).

14. Provide additional funding and guidance for landowners to provide essential resources for nesting tricolors on private property.

15. Actively maintain all wetlands recently used by breeding tricolors, and especially those in coastal locations, to provide the youthful conditions preferred by nesting birds.

16. Develop and disseminate via the Portal handbooks that illustrate best practices for maintaining wetlands and other nesting substrates for breeding by tricolored blackbirds.

17. Conduct threat assessments of all areas currently used by breeding tricolors and work with local officials to identify these threats and seek ways to reduce or eliminate them.

18. Assess the concentrations of neonicotinoid insecticides in regions with the lowest insect abundances and highest rates of decline in tricolored blackbirds.

Beedy (2014) offered additional suggestions specifically regarding cattle ranching:

1. Recognize that cattle ranching and most other range management activities have mostly beneficial effects on this species and do not result in incidental take;

2. Consider authorizing limited incidental take consistent with typical cattle ranching and range management activities;

3. Establish financial incentive programs to encourage ranchers and farmers to voluntarily create and manage suitable habitats in the context of their normal operations;

4. Educate ranchers, farmers, and other members of the public about the benefits of this species in the control of harmful insect pests that damage agricultural crops.

The Tricolored Blackbird Action Group of the Yosemite Area Audubon Society has created a database of shovel-ready projects to lure Tricolored Blackbirds to secure breeding habitat. These sites include an assessment of the availability of insect-rich foraging habitat and water sources. Similar projects could be expanded to other areas as well outside of the Sierra Nevada foothills.

In addition, efforts are needed by the State and Federal agencies to enhance breeding habitat on wildlife areas and other public lands.

The Center strongly encourages funds to be made available for the highest-priority of these projects, along with funding for scientific monitoring of results.

10.0 Availability and Sources of Information

Literature cited in this petition is listed below. A disk with many of the critical documents cited will be send via U.S. Mail to the Commission along with a paper copy of the petition.

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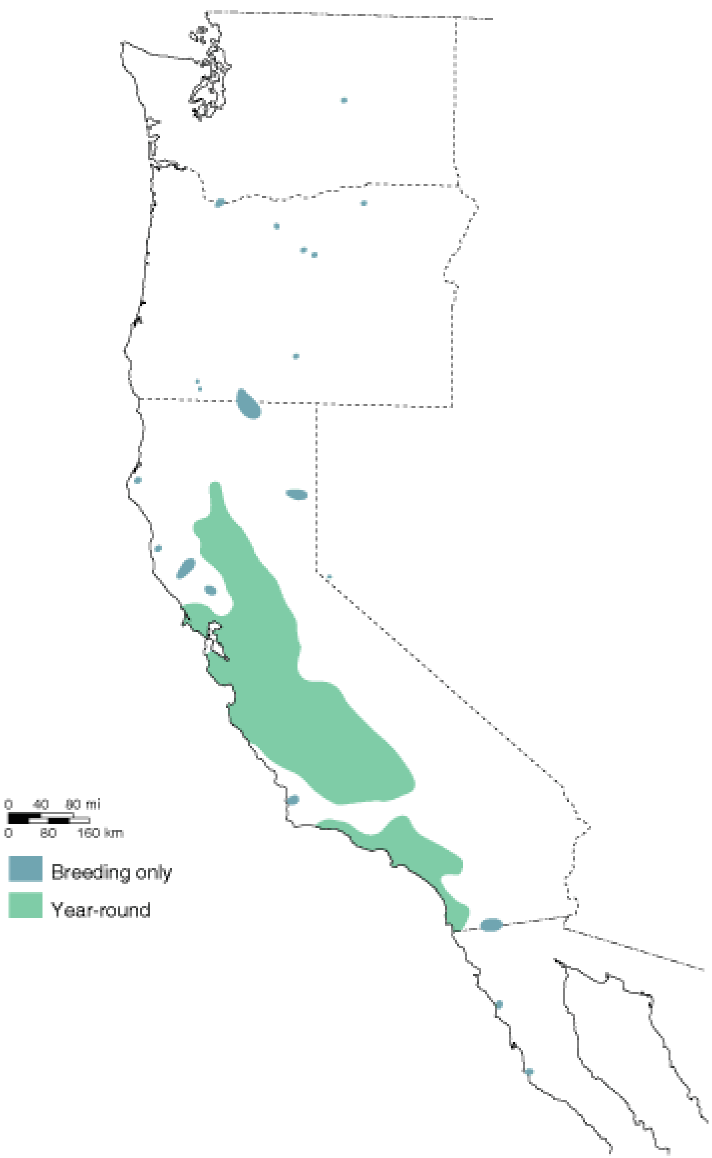
11. Detailed Distribution Map



Distribution of Tricolored Blackbirds (Meese et al. 2014)

2015 Addendum to
Petition to List the Tricolored Blackbird (*Agelaius tricolor*) as Endangered under the California Endangered Species Act and Request for Emergency Action to Protect the Species

In response to the Center for Biological Diversity's 2014 petition, the Commission provided Emergency Listing Protections for the species from December 29, 2014 through June 30, 2015. With the expiration of those emergency protections, Tricolored Blackbird remains at significant threat of extinction.

Two new relevant studies are attached hereto as an addendum to the petition and incorporated by reference. Holyoak et al. 2014 analyzed declines in breeding success of the Tricolored Blackbird and Meese 2015 reviews and evaluates efforts to document the status of the Tricolored Blackbird since 1931.

Holyoak M., Meese R.J., Graves E.E. 2014. Combining Site Occupancy, Breeding Population Sizes and Reproductive Success to Calculate Time-Averaged Reproductive Output of Different Habitat Types: An Application to Tricolored Blackbirds. PLoS ONE 9(5): e96980. doi:10.1371/journal.pone.0096980

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Combining Site Occupancy, Breeding Population Sizes and Reproductive Success to Calculate Time-Averaged Reproductive Output of Different Habitat Types: An Application to Tricolored Blackbirds

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Abstract

In metapopulations in which habitat patches vary in quality and occupancy it can be complicated to calculate the net time-averaged contribution to reproduction of particular populations. Surprisingly, few indices have been proposed for this purpose. We combined occupancy, abundance, frequency of occurrence, and reproductive success to determine the net value of different sites through time and applied this method to a bird of conservation concern. The Tricolored Blackbird (*Agelaius tricolor*) has experienced large population declines, is the most colonial songbird in North America, is largely confined to California, and breeds itinerantly in multiple habitat types. It has had chronically low reproductive success in recent years. Although young produced per nest have previously been compared across habitats, no study has simultaneously considered site occupancy and reproductive success. Combining occupancy, abundance, frequency of occurrence, reproductive success and nest failure rate we found that that large colonies in grain fields fail frequently because of nest destruction due to harvest prior to fledging. Consequently, net time-averaged reproductive output is low compared to colonies in non-native Himalayan blackberry or thistles, and native stinging nettles. Cattail marshes have intermediate reproductive output, but their reproductive output might be improved by active management. Harvest of grain-field colonies necessitates either promoting delay of harvest or creating alternative, more secure nesting habitats. Stinging nettle and marsh colonies offer the main potential sources for restoration or native habitat creation. From 2005–2011 breeding site occupancy declined 3x faster than new breeding colonies were formed, indicating a rapid decline in occupancy. Total abundance showed a similar decline. Causes of variation in the value for reproduction of nesting substrates and factors behind continuing population declines merit urgent investigation. The method we employ should be useful in other metapopulation studies for calculating time-averaged reproductive output for different sites.

Citation: Holyoak M, Meese RJ, Graves EE (2014) Combining Site Occupancy, Breeding Population Sizes and Reproductive Success to Calculate Time-Averaged Reproductive Output of Different Habitat Types: An Application to Tricolored Blackbirds. PLoS ONE 9(5): e96980. doi:10.1371/journal.pone.0096980

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Introduction

A common conservation aim is to understand the relative roles of altered habitat characteristics versus fragmentation in population declines. Armstrong [1] stated this as the need to distinguish between the habitat and metapopulation paradigms. Specifically, that we needed to identify how population declines and dynamics are influenced by habitat characteristics (e.g., in species' distribution or niche models [2]), and the metapopulation processes of extinction and colonization [3,4]). Here we tackle the question of how to evaluate the contribution to long-term regional dynamics of breeding populations in habitat patches of different types when patches do not remain continuously occupied. Our focus is on breeding populations because our study species, the Tricolored Blackbird (*Agelaius tricolor*), is widely dispersed when it is not breeding, and consequently it is difficult to census outside of the breeding season. Spatial concentration of numbers during the breeding season is also observed in a variety of organisms, including various land birds, pond-breeding amphibians and aquatic insects. Additionally in our study species, Tricolored Blackbirds, low breeding success has been highlighted as a problem during 2006–2011 [5]. We calculate a time-averaged index of reproduction that we believe will be of interest to those studying metapopulations of other organisms that do not use the same sites in all breeding seasons.

The Tricolored Blackbird, a medium-sized songbird that is geographically restricted to California and small portions of adjacent states in the western United States, experienced declines in total abundance on the order of 89% from the 1930's to 1980's [6] and average colony size declines of over 60% between the 1930's and 1970's [7]. The species receives legal protection under the Migratory Bird Treaty Act and is classified as a bird species of conservation concern by the US Fish and Wildlife Service [8], and California Species of Special Concern since 1990 [9]. Additionally, it is treated as a sensitive species by the Bureau of Land Management since 1999 [10], and it has been listed on the IUCN red list of endangered species since 2006 [11]. The Tricolored Blackbird is the most colonial extant songbird in North America [12], and historically breeding colonies consisting of up to 200000 nests were recorded [13]. The species historically nested primarily in cattail (*Typha* spp.) or tule (*Schoenoplectus* spp.) marshes, but was observed to nest in a wide variety of wetland and upland habitats [13]. From the 1970's onwards the species was increasingly recorded nesting in invasive Himalayan blackberry (*Rubus armeniacus* [9], and silage crops, especially "triticale" [14,15]. The largest recently recorded colonies have mostly occurred in triticale, a wheat [*Triticum*] x rye [*Secale*] hybrid grain grown for dairy cows, and are at risk of being destroyed when the fields are harvested before the young have fledged [5,14,15]. Recently, a federally funded program has paid farmers to delay the harvest of triticale fields occupied by breeding tricolors until after the young have fledged and left the area [16]; however, participation in this program is voluntary and not all eligible farmers participate. We previously showed that long-term (1930's to 1980's) trends in the average size of breeding colonies (numbers of birds) varied both among geographical regions and nesting substrates [7]. Cook and Toft [15] also reported that reproductive success (number of 7–9 day old chicks per nest) was greater for colonies nesting in Himalayan blackberry than for those in native cattail or tule marshes. Additionally, silage colonies had low average reproductive success because of harvest before young birds fledged [15]. Considering only non-harvested colonies, Cook and Toft [15] found that silage colonies produced more offspring per nest than cattail or tule marsh colonies. Meese [5] found no differences in reproductive success among nesting substrate types in a sample of 47 colonies. Weintraub [17] also examined whether reproductive success of colonies in silage differed from that in marsh colonies as part of a Master's thesis study, but found no differences for the 14 colonies studied. Overall, while there have been several studies of population trends (or size) and some studies of reproductive success, no study has simultaneously considered occupancy of sites and reproductive success to determine the time-averaged net value of different habitats for conservation and management.

The occupancy of breeding habitat areas, the sizes of breeding populations, and the reproductive success of breeding efforts are often readily documented, but demographic data for the rest of the life cycle are much harder to obtain. This is especially the case for species that are more widely dispersed in the non-breeding season than when breeding, such as many imperiled birds, amphibians, and aquatic insects. We often lack a good understanding of both the dispersal between populations and survival outside of the breeding season. This arises because dispersal and survival are difficult to measure (e.g., [18,19,20]). These data gaps are typically found in imperiled species where low abundances or restricted distribution may limit study or present ethical considerations. Consequently, conservation biologists have adopted a variety of techniques to look at habitat effects on population dynamics.

One common method is to calculate finite growth rates and apply a source-sink approach [21,22]. However, without information about movement there is a risk of confusing habitat-specific demography with movement [23]. A source-sink approach can also be applied by using available information for reproduction in different habitats and assuming that survival has a constant value [24] and that movement does not confound measurement of finite growth rates. Such additional assumptions (about survival and dispersal) are frequently masked and increase uncertainty in the predictions made about population status. More directly, data on reproductive success is often used to identify ecological traps (e.g., [25]), although such an approach usually ignores data on the occupancy and population size in different habitats (e.g., reviewed by [26]). Of course there are studies of both source-sink dynamics and ecological traps for cases where more complete year-round data are available and movement was quantified, but this is often not the case for imperiled species. We here use a simple parsimonious method for calculating the net value for reproduction of sites in different breeding habitats by combining occupancy, abundance and reproductive data. We believe that our time-averaging approach will be useful for other species for which occupancy, abundance, and reproductive success data are available but where survival or movement data are lacking. Our approach has a more direct connection to existing data and avoids using additional assumptions to make conservation and management recommendations.

We evaluated the net value of typical sites in different breeding habitats for reproduction of Tricolored Blackbirds. Our focus was on the nesting substrate rather than the habitat surrounding nesting sites, which is used for foraging [14], and within which insect abundance at foraging locations is related to reproductive success [5]. We evaluated the net value of different nesting habitats for production of offspring by looking at the following questions: (1) Does frequency of occupancy, site extinction, or site recolonization vary by nesting substrate? (2) Does the duration of occupancy vary by nesting substrate? (3) Does reproductive success vary by nesting substrate? (4) Statewide, how frequently are breeding colonies recorded in different substrates, what are their sizes, and have their frequencies and sizes changed in recent decades? (5) Is it useful to combine the above information to obtain an overall idea of the net value of colonies in different nesting substrates in a typical year? Answering these questions allows us to provide new conservation recommendations for Tricolored Blackbirds and a methodology that is likely of broader interest to those studying the value of different breeding habitats for imperiled species.

Methods

Ethics

No animals were handled as a part of this study and no permits were required. The study species is not currently protected by the state or federal Endangered Species Acts which would require such permits. Some study sites are privately owned and the landowners of these sites provided access or they were viewed from nearby public rights of way without accessing the land.

Data sources and availability

We use data from three different sources that are all publicly available:

Dataset 1. For colony occupancy and reproductive success from 2006 to 2011 we used data collected by RJM together with 2005 data collected jointly by RJM and William J. Hamilton, III. These data are already available through the public Tricolored Blackbird Portal (http://tricolor.ice.ucdavis.edu) and the explicit dataset will be made available and archived through *Dryad* (http://datadryad.org/) when this manuscript is published. This dataset includes 26 distinct sites and a total of 45 records for which reproductive success values were estimated [5].

Dataset 2. For a broader view of reproductive success we used data collected during extensive fieldwork by the late William J. Hamilton, III (WJH) between 1992 and 2005 (a few colonies were sampled jointly with RJM in 2005). These data are available in a public archive, the Knowledge Network for Biocomplexity [27]. WJH's data represent the most extensive source of information on reproductive success available for this species: it includes assessment of 128 distinct breeding sites containing colonies, and 191 records including repeated annual measurements at the same colonies, during 1992-2005. There were 2–30 colonies per year. These data up to 2000 are also discussed by Hamilton [28] but were not then formally analyzed or summarized. We have not included WJH as a coauthor since we have no way of knowing whether he would have agreed with the messages in our paper and instead directly cite the data source [27]. We did not use this dataset for occupancy analyses because it is not always clear which colonies were checked when reproductive success data were not collected.

Dataset 3. We used statewide survey data to obtain a broader view of the frequency of colonies in different breeding substrates and the size of such colonies. These data were used by Graves et al. [7] and are available in the public *Dryad* data archive ([29], file "Graves_et_al_data1.csv").

Empirical evaluations of reproductive success

Fieldwork generally began in late March in the southern San Joaquin Valley, where breeding commences earliest in the Central Valley, and progressed to the Sacramento Valley as the season progressed and birds move to breed again [30]. A full description of field methods are given by Meese [5], and these reflect general protocols as used by WJH. For example, the number of breeding birds in a colony was estimated either visually at the time of nesting and/or by nest sampling following the breeding season. Nest numbers were multiplied by 1.5 to estimate the number of breeding birds, which reflects that on average each male nests with two females [14]. If visual estimates of the numbers of breeding birds differed from estimates derived from direct counts of nests, the estimate derived from the direct count of nests was used because it was thought to be more accurate.

Analyses of Occupancy, Cessation of Use, Colonization and Survival of Breeding Colonies

Breeding colonies can be treated in analogous ways to populations within a metapopulation [3] with rates of patch occupancy resulting from extinction and colonization. However, because the breeding birds using colonies do not in most cases die, we avoid referring to extinction of colonies and instead refer to "cessation of use" for breeding each year. It should however be noted that in metapopulations when a local population experiences an extinction the individuals may also have moved to another habitat patch, so the metapopulation analogy is quite strong. Analyses in this section used occupancy information from Dataset 1.

We scored nesting sites as "occupied" when birds were present and breeding, and "unoccupied" when sites were visited but breeding birds were not found at any point during the annual monitoring period (the species' breeding season); hence sites with no information were not recorded as either unoccupied or occupied. Occupancy was analyzed using linear mixed effects models (using *lmer* in the *lme4* package in *R* [31]) with a logit link function and binomial error distribution, which are appropriate for binary data (occupied or not). In this analysis and all similar analyses, p-values ("pMCMC") were calculated using Markov-chain Monte Carlo sampling using the function pvals.fnc from R library language [32]. Models used year as a random factor to account for repeated measures in the error structure (we also investigated using site identity as a random factor but model fit was not improved, as measured using AICc, and results were similar). We excluded substrates that had less than five total records because the sample sizes were too small to provide reliable estimates of occupancy; these included colonies situated in *Arundo donax*, buttonbush (*Cephalanthus occidentalis*), mesquite (*Prosopis* sp.), and oats (*Avena sativa*). Sample sizes for included substrates are given as the numbers above the bars in Figure 1A. We attempted to include models with the number of breeding birds as a covariate (including interactions with breeding substrate type), or the same for the area of occupied habitat prior to extinction, but neither improved model fit and we therefore do not report the results further. Because preliminary analyses indicated substantial variation in occupancy from year to year we included year as a fixed effect in the model (in addition to as a random effect to allow for repeated measures; removing the random effect of year also did not produce substantial changes in the fixed effect for year, indicating that temporal autocorrelation was weak).

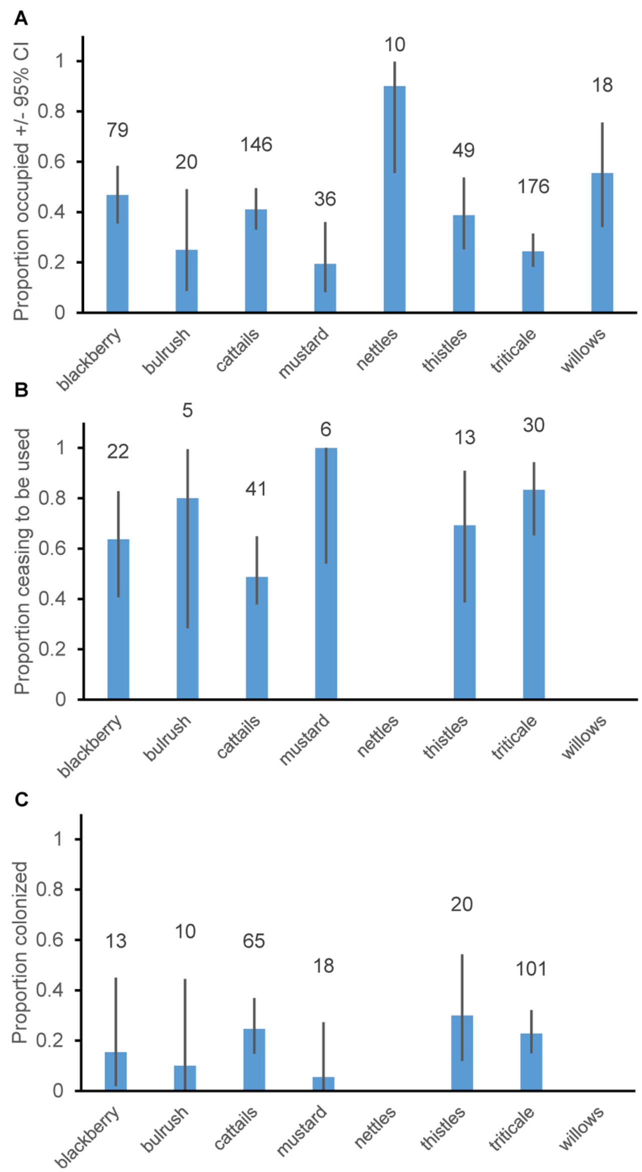

Figure 1. Mean proportion of breeding sites A. occupied, B. showing extinction or C. colonization per year. Numbers above bars indicate sample sizes. Error bars show 95% confidence intervals from a binomial distribution. Nettles and willows are not shown in b and c because sample sizes were less than 5.
doi:10.1371/journal.pone.0096980.g001

Table 1. ANOVA-style results of linear mixed effects models testing for differences in occupancy.

Fixed Effects:	SS	DF	MS	F	p	h^2
Substrate	8.52	7	1.22	5.79	0.001	0.07
Year	4.33	6		38.46	0.003	0.04
Error	109.55	520	0.21			

The whole model adjusted R^2-value was 11%. Random effects were: Year (Intercept) variance = 0.11423, standard deviation = 0.33798, from 534 observations in 7 groups (years). Effect size is given as the proportion of variance explained by explanatory variables, partial eta-squared (h^2) = (SS_{effect})/(SS_{effect}+SS_{error}).
doi:10.1371/journal.pone.0096980.t001

A "cessation of use" event was recorded as occurring when a site was occupied by breeding birds in year *t*-1 and was not occupied in year *t*, which could have occurred either because the habitat became unsuitable (e.g., many triticale fields) or because the habitat was present and suitable, but birds no longer used it for breeding. Cessations of use were recorded as possible when a site was occupied in year *t*-1 and was monitored for nesting birds in year *t*; this procedure avoided censoring of the data. For the probability of cessation-of-use analyses we used linear mixed effects models in the same way as for occupancy listed above including covariates and year as a fixed effect. Only nesting substrate improved model fit based on delta AIC values and for brevity we do not report the factors and covariates that did not improve model fit. We included nesting substrates if there were at least 5 possible extinctions within each (sample sizes in Figure 1B), and this restriction resulted in exclusion of *Arundo*, bulrush, buttonbush, mesquite, nettles, oats, and willow substrates.

A "colonization" was recorded for sites from 2006 onwards if a site was unoccupied in year *t*-1 and became occupied in the current year *t*. Our data represent a mix of colonizations of sites that were likely unoccupied during our study and recolonizations of sites that had experienced cessations of use during our study period. Analysis was conducted in the same way as for occupancy and cessations of use, and sample sizes for included substrates are reported in Figure 1C.

We also analyzed for how many years colonies remained occupied in common breeding substrates (blackberry, cattails, thistle and triticale), and refer to this as "colony longevity." (We use the term as a shorthand while recognizing that colonies may relocate rather than dying, hence colony longevity represents the duration of occupancy of a site.) The analysis was formerly a survival analysis using the *survreg* function from library *Survival* in *R* [33]. Preliminary analyses showed that parametric survival analyses were more informative than non-parametric (Cox's proportional hazards) analyses, and that models with a Weibull hazard function (describing instantaneous risk of death) were a significantly better fit to the data than those with an exponential hazard function. The analysis recognized that data are censored both because some colonies remained occupied by breeding birds during the breeding seasons throughout the study period and we do not know when some sites were colonized.

Analyses of Reproductive Success

Datasets 1 and 2 were used to assess reproductive success (RS) of colonies. RS was defined as the number of chicks alive per nest at c. 7–9 days after hatching of the first egg. RS was estimated either by visual estimates or by sampling. Visual estimates of RS were derived from the estimates of the number of breeding birds obtained during monitoring and the number of fledglings observed at the end of the breeding season. Because one male breeds, on average, with two females [14], each two nests have three birds

Table 2. Parameter values from linear mixed effects models testing for differences in occupancy.

Parameter type	Group	Parameter	SE	z	p
Mean	cattails, 2005	0.058	0.30	0.19	0.85
difference in mean	mustard	-1.11	0.46	−2.40	0.02
difference in mean	blackberry	0.34	0.29	1.16	0.25
difference in mean	bulrush	−0.78	0.55	−1.42	0.16
difference in mean	nettles	2.98	1.08	2.74	0.006
difference in mean	thistle	−0.02	0.35	−0.06	0.95
difference in mean	triticale	−0.82	0.25	−3.32	0.001
difference in mean	willow	0.69	0.53	1.31	0.19
difference in mean	2006	−0.44	0.38	−1.17	0.24
difference in mean	2007	−0.37	0.39	−0.96	0.34
difference in mean	2008	0.12	0.35	0.34	0.73
difference in mean	2009	−0.34	0.36	−0.96	0.34
difference in mean	2010	−0.48	0.38	−1.27	0.20
difference in mean	2011	−1.23	0.36	−3.46	0.001

The mean value of logit-transformed occupancy is given for cattails in 2005, and then other rows of the table give the difference (in logit-transformed mean occupancy) from this value for the groups indicated.
doi:10.1371/journal.pone.0096980.t002

Table 3. ANOVA-style results of linear mixed effects models testing for differences in the proportion of colonized sites where occupancy for breeding ceased per year.

Fixed Effects:	SS	DF	MS	F	P	h^2
Substrate	2.93	5	0.59	2.82	0.019	0.11
Error	23.07	111	0.21			

Random effects were: Year (Intercept) variance = 3.8×10^{-13}, standard deviation = 6.2×10^{-7}, from 117 observations in 6 groups (years). Effect size is given as the proportion of variance explained by explanatory variables, partial eta-squared (h^2) = $(SS_{effect})/(SS_{effect}+SS_{error})$.
doi:10.1371/journal.pone.0096980.t003

associated with them, so the product of the number of breeding birds multiplied by 2/3 (0.67) provides an estimate of the number of nests constructed. The number of young fledged divided by the estimate of the number of nests constructed yields an estimate of the number of young fledged per nest (RS).

Average reproductive success (RS) combines the numbers of offspring in successful nests with zero values that come from failed nests. Nests may fail entirely because of physical conditions (destruction during high winds, extreme temperatures, etc.) as well as predation [9]. It is therefore useful to separately consider rates of nest failure from reproduction in nests that were successful. To this end Hamilton calculated the reproductive rate for the subset of nests that were successful up to 7–9 days old, termed RSS (reproductive success of successful nests).

Because of differences in timing and observers we initially analyzed the two datasets separately. However, both visual plots and individual *lmer* models failed to find differences between the datasets, and so here we report a combined analysis. We used linear mixed effects models with colony identity as a random factor to allow for repeated measurements from individual colonies. Year, substrate and collector identity (Hamilton or RJM) were factors with fixed effects, and we also assessed year by substrate interactions but found no significant ($P<0.1$) effects for such interactions and do not report these results further. Collector identity (and interactions with other factors) also produced an increase in the AICc value of the model indicating that a simpler model without this variable was preferred and we therefore do not report this effect further.

Analyses of Colonies in Different Substrates and Colony Size

We used Dataset 3 and specifically records from 1980 through 2011. We summarized the proportion of records in each breeding substrate per decade and average colony size (number of birds ln-transformed) by decade (1980–1989, 1990–1999, 2000–2009, and 2010–11). Recent colony sizes were calculated using ln(birds) per colony from 2000 to 2011 inclusive.

Recent colony sizes and reproductive success (RS) estimates from either Datasets 1 or 2 were used to estimate the total predicted production of chicks (to day 8) for average size colonies in each of the common substrates. To give an idea of variation in chick production per spring breeding per colony in each substrate we calculated a standard deviation: Standard deviations of the numbers of chicks produced were calculated as $x.\sqrt{(s_1^2+s_2^2)}$, where x is the estimated number of chicks produced for a particular substrate, s_1 is the proportional standard deviation for colony size (standard deviation of colony size/mean colony size), and s_2 is the proportional standard deviation for reproductive success in the same substrate. Lastly, to allow for the fact that not all sites are occupied in all years we multiplied chick production by occupancy to calculate chick production across an average site of each substrate. A measure of variation could not easily be calculated for this measure but the standard deviation would likely encompass zero values (no chicks produced) for all substrates because variation in RS, colony size, and occupancy are all relatively large.

Results

Occupancy, Cessation of Use, Colonization and Longevity of Colonies

Average proportional occupancy of breeding sites varied widely across sites and substrates (Figure 1A). Average breeding site occupancy was significantly lower for triticale and mustard growing as a weed within grain fields, than for other breeding substrates with sufficient sample sizes (cattails, blackberry, bulrush, nettles, thistle and willow). Cattails, blackberry, bulrush, nettles, thistle and willow were similar (at $P>0.1$) to one-another in their levels of site occupancy (Figure 1A for differences and Tables 1, 2

Table 4. Parameter values from linear mixed effects models testing for differences in the proportion of colonized sites where occupancy for breeding ceased per year.

Parameter type	Group	Parameter	SE	z	p
Mean	cattails	−0.049	0.31	−0.16	0.88
difference in mean	mustard	16.6	1615	0.01	0.99
difference in mean	blackberry	0.61	0.54	1.12	0.26
difference in mean	bulrush	1.44	1.16	1.24	0.22
difference in mean	thistle	0.86	0.68	1.27	0.20
difference in mean	triticale	1.66	0.58	2.85	0.004

The mean value of logit-transformed proportion of sites with cessation of breeding is given for cattails, and then other rows of the table give the difference (in logit-transformed mean proportion) from this value for the groups indicated.
doi:10.1371/journal.pone.0096980.t004

Table 5. ANOVA-style results of linear mixed effects models testing for differences in the proportion of vacant sites with colonizations per year.

Fixed Effects:	SS	DF	MS	F	P	h^2
Substrate	0.86	5	0.17	1.01	0.41	0.02
Error	37.6	221	0.17			

Random effects were: Year (Intercept) variance = 0.004, standard deviation = 0.066, from 227 observations in 6 groups (years). Effect size is given as the proportion of variance explained by explanatory variables, partial eta-squared (h^2) = $(SS_{effect})/(SS_{effect}+SS_{error})$.
doi:10.1371/journal.pone.0096980.t005

for statistics). Nettle sites had higher than average occupancy, and showed significantly higher occupancy than other substrates except willows (Figure 1A and Tables 1, 2).

The rate of cessation of breeding at sites that were used for breeding in previous years was generally frequent, with an average of 66% of sites per year ceasing to be occupied by breeding birds. This rate was significantly higher for triticale fields (83% of sites per year) than for cattail sites (49%; Figure 1B; Tables 3, 4). Data on cessation of use of breeding sites were sparse for blackberry, bulrush, mustard, nettle and willow sites (Figure 1B), which might account for a lack of any statistical differences (at $P<0.1$) in the frequency of cessation of use of sites in these substrates compared to other substrates. Although with a small sample size it is noteworthy that like triticale sites, mustard sites showed a high average rate of extinction (100%). This likely reflects either that annual crops were not planted in the same place each year or that weeds in such fields were removed by herbicide application, forcing extinction through a lack of habitat in the form of both the crop itself and mustard as a weed within such crops.

For the six substrates with calculable rates at which they ceased to be used for breeding, these rates were strongly negatively correlated with occupancy (Pearson's $r = -0.87$, $P<0.025$ in a 1-tailed test). The overall pattern is that the two temporary habitats, triticale and mustard, showed lower occupancy (Figure 1A) and higher observed rates of cessation of use (Figure 1B) than other types of breeding site. This likely reflects habitat loss either through herbicide use on weeds that Tricolored Blackbirds frequently nest in (e.g., mustard) or because of crop rotations. The two substrates for which rates of cessation of use could not be calculated (because $n<5$) were nettles and willows, both of which showed very high occupancy (Figure 1A) and thus experienced very few cessations of use.

Colonization rates were generally low, with only 21.1% of sites per year being colonized each year. *LMER* models showed no significant difference (at $P<0.1$) for any substrate or overall (Tables 5, 6). Across the full suite of sites for which we had occupancy data the low colonization rates (21%/year) relative to cessation rates (66% sites/year) could either reflect a declining (nonequilibrium) metapopulation or that colonizations are under-recorded.

Analysis of the numbers of years for which sites remained in use by breeding colonies using survival analysis revealed that the slope of survivorship versus age of colonies declined with colony age (scale parameter = 0.436, Table 7). Hence colonies that were occupied for more than 1 year were less likely to cease being occupied during their second year than their first year (Figure 2). Continued use of sites in cattail marshes was more likely than for triticale sites (Figure 2, Table 7). This accords with the high per year cessation-of-use rates of triticale colonies compared to cattail marsh colonies (Figure 1B, Tables 3, 4). Survivorship slope declining less sharply in older colonies can most clearly be seen in cattail colonies (Figure 2), whereas triticale colonies frequently ceased to be used after one year, and sample sizes were small because there were few uncensored records for blackberry and thistle colonies.

Reproductive Success

Reproductive success (RS) varied substantially among nesting substrates, and for habitats with at least 5 RS values substrate accounted for 59% of the variation in RS values (Tables 8, 9). Himalayan blackberry colonies had a greater average reproductive success than marshes, grain fields, and thistle habitats (Tables 8, 9; Figure 3A). The sample size for RS estimates from nettles was low (Figure 3A) and statistically there was no difference from other substrates (Tables 8, 9), but RS values were high and grouped together with blackberry. There were only 4 RS estimates from colonies in willows and the RS values were low and seemed similar to thistle, marsh and grain field colonies. The analysis reported in

Table 6. Parameter values from linear mixed effects models testing for differences in the proportion of vacant sites colonized per year.

Parameter type	Group	Parameter	SE	z	P
Mean	cattails	−1.12	0.29	−3.87	0.001
difference in mean	mustard	−1.72	1.07	−1.61	0.11
difference in mean	blackberry	−0.59	0.82	−0.71	0.48
difference in mean	Bulrush	−1.08	1.09	−0.99	0.32
difference in mean	Thistle	0.27	0.57	0.48	0.63
difference in mean	triticale	−0.10	0.37	−0.27	0.79

The mean value of logit-transformed proportion colonized is given for cattails, and then other rows of the table give the difference (in logit-transformed mean proportion colonized) from this value for the groups indicated.
doi:10.1371/journal.pone.0096980.t006

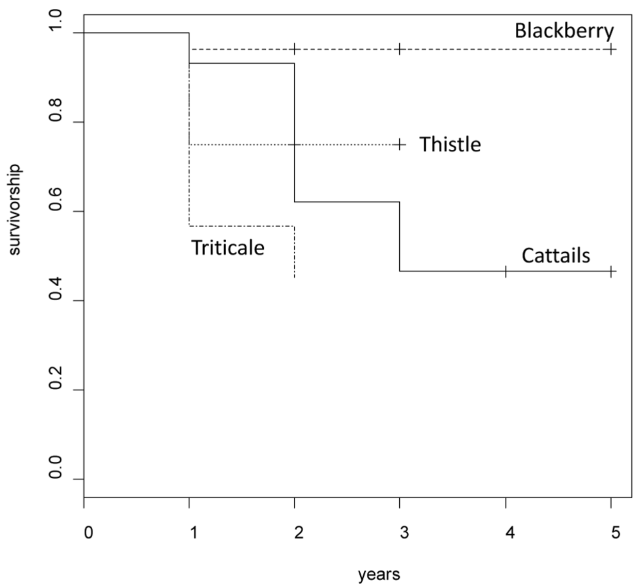

Figure 2. Survivorship for breeding colonies in different substrates. The vertical crosses (plus symbols) indicate that datapoints were constrained by censoring of the data. Note that for Blackberry there was only one non-censored event and so the survivorship values are limited by sample size and are likely not reliable.
doi:10.1371/journal.pone.0096980.g002

Tables 8, 9 did not find any significant (P<0.1) effects of observer (Hamilton or Meese) or year on RS values and so the above results represent a compilation of the datasets. Colony size (estimated number of birds) did not have any statistical effects on RS in the linear mixed effects models, nor did colony area (square meters) in the Meese data (and was not collected for the Hamilton data).

Reproductive success results in part from complete failure of nests, from sampled nests in which eggs were never laid, and in part from reduced numbers of chicks in nests that survive to the time of recording (day 7–9). Figure 3C shows that a low proportion of nests was successful at rearing young in marsh habitats compared to those in Himalayan blackberry and grain field sites. Stinging nettle sites appeared intermediate and variable (likely because of small sample sizes; Figure 3C). Interestingly nesting substrate accounted for only 15% of variance in RSS compared to the 54% in RS, indicating that nesting substrate had a more predictable effect on whether nests failed or succeeded in raising some chicks rather than on the numbers of chicks produced. As with RS, RSS was relatively high for Himalayan blackberry colonies (Tables 10, 11, Figure 3B). Grain fields had lower RSS than Himalayan blackberry colonies, and nettle colonies had higher RSS than Himalayan blackberry colonies (and grain fields; Tables 10, 11, Figure 3B). Marsh colonies had lower reproductive success than Himalayan blackberry colonies but significance was marginal (pMCMC = 0.056; Tables 10, 11), reflecting small sample size for RSS from marshes. RSS for marsh colonies was similar to that from grain field colonies (Figure 3B).

Frequencies of Colonies in Different Substrates and Colony Size

Figure 4A shows that colonies were most frequent in marsh habitats (cattails and bulrush) followed by blackberries and thistles. Records in grain fields (primarily triticale but also mustard within triticale) have grown steadily to represent 8.6% of colonies in 2010–2011. The proportion of records grew through time for both nettles (reaching 10.2% of records in 2010–11) and thistle (12.7% of records in 2010–11). Conversely the proportion of records in marsh habitats declined steadily through time (Figure 4A), from 51.7% in the 1980's to 33% in 2010–11. With the exception of thistle colonies, the average size (number of birds) of colonies in common substrates was smaller in 2010–11 than in previous decades (Figure 4B). The decline was most dramatic for grain crops (Figure 4B). For the period 2000 to 2011 inclusive, representing recent records (without putting too much emphasis on 2010–11) Figure 4C shows average colony sizes. Grain field colonies were by far the largest on average size, with a mean of 995 birds. Other colonies on average had 312 birds in blackberry, 290 for thistle (and milk thistle, *Silybum marianum*), 224 birds for nettle, 215 birds in marsh substrates and the few willow sites were smallest of all (135 birds).

Predictions of the numbers of chicks that would have been produced by average size colonies were in general highly variable, reflecting that both the RS estimates and colony size estimates were also variable. Putting together RS estimates and average (2000–2011) colony sizes leads to the prediction that blackberry and grain field colonies produced the most chicks on average (Figure 4D). This was followed by stinging nettle colonies and then thistle colonies (Figure 4D). Marsh sites produced smaller numbers of chicks on average but they were still about twice as productive as willow sites (Figure 4D). Incorporating occupancy into our analysis across the years shows that nettle sites were the most productive (with a mean of 221 chicks per site per year; Figure 4D) because they have high occupancy, followed by blackberry sites (174 chicks/site/year). (An average grain field in an average year produced 65 chicks, but this figure is not very relevant because grain fields are generally not conserved from year to year). Thistle sites produced an average of 44 birds/site/year, and surprisingly marsh sites produced an average of only 34 birds/sites/year reflecting that their occupancy was low. The few willow sites produced an average of 26 birds per year. Clearly conserving triticale (grain) fields when they are occupied is especially valuable and this is possible because the habitat is not permanent. Apart

Table 7. Results of parametric survival analysis for breeding colonies using a Weibull hazards function.

Parameter type	Group	Parameter	SE	z	p
Mean	Cattails	1.355	0.169	8.03	0.001
difference in mean	blackberry	0.582	0.476	1.22	0.21
difference in mean	Thistles	−0.334	0.301	−1.11	0.27
difference in mean	Triticale	−0.805	0.202	−3.99	0.001

The model was significantly preferred over an intercept-only model (Chi-squared = 22.44 with 3 degrees of freedom, p<0.001). Weibull scale parameter = 0.436. The mean value of survival is given for cattails, and then other rows of the table give the difference from this value for the groups indicated.
doi:10.1371/journal.pone.0096980.t007

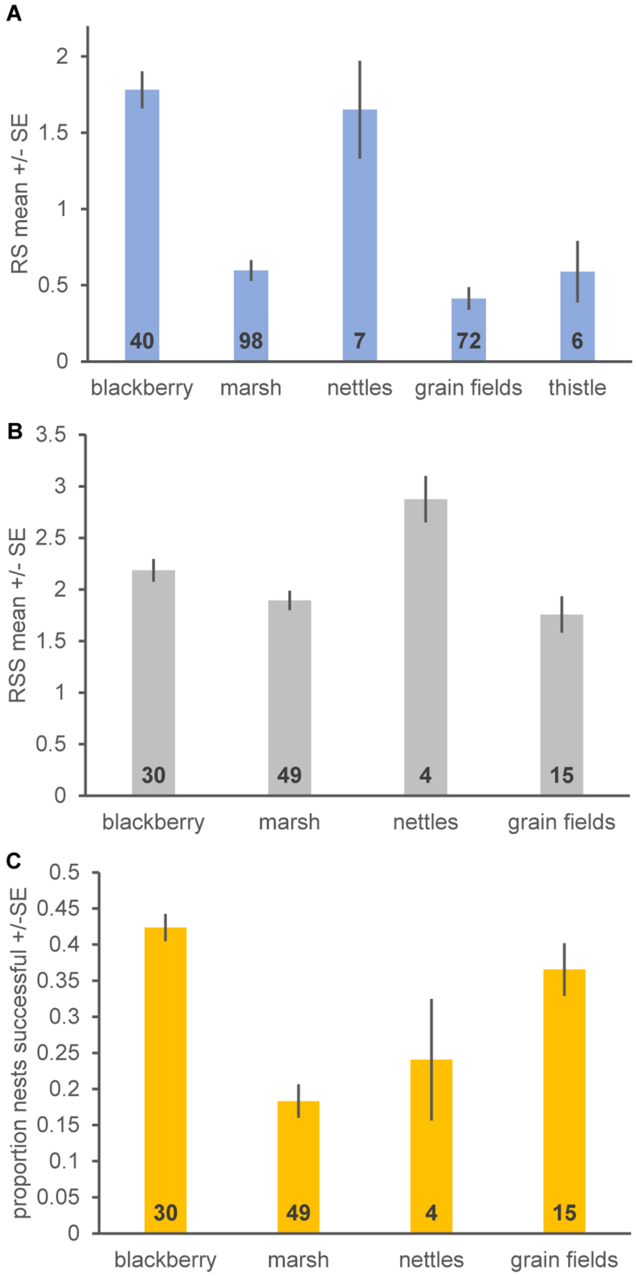

Figure 3. Reproductive success estimates for different breeding substrates. Estimates of **A**, reproductive success (RS), defined as the average number of chicks per nest at c. 8 days after the first egg hatched, **B** reproductive success of nests that were successful in rearing some young to day 8 (RSS), and **C** the proportion of nests that were successful in rearing some young to 7–9 days-old. Data in **A** come from Hamilton and RJM, and those in **B** and **C** come from Hamilton. Bars indicate standard errors. Numbers inside the base of bars indicate sample sizes (colonies x years, reflecting that these data include some repeated measurements).
doi:10.1371/journal.pone.0096980.g003

from this, considering occupancy leads to the prediction that average nettle sites are disproportionately important in chick production, as are blackberry sites, whereas thistle sites are less important and marsh sites are close to least important of the nesting substrates commonly used by Tricolored Blackbirds.

Discussion

Our analyses demonstrate a simple direct method for combining data on breeding site occupancy, breeding population sizes and reproductive success to calculate the net metric for the value of different habitats for reproduction. In our case because we had time series of occupancy values for each site, we calculated time-averaged values for reproductive success, but such calculations could also be made using one-time (snapshot) estimates of occupancy, abundance and reproduction. Such direct calculations avoid making additional assumptions about survival (outside of the breeding season) and dispersal that would be required to apply a source-sink model (e.g., [21]) to species where we have data only on breeding populations. We believe that such calculations would also benefit studies of other imperiled bird species, as well as other taxa where we can readily obtain data only on breeding success and breeding populations because individuals are more widely dispersed when not breeding. It is surprising that previously (as far as we can determine) such an index has not been described. Our calculations assume that there is turnover of occupancy in sites, as is usually the case in fragmented populations and metapopulations [20].

Calculation of the average number of offspring produced per site in an average year provides a method of assessing the conservation value of different breeding substrates (Figure 4D). An assessment of the components making up this number, like that in Table 12, helps us understand multiple components of the value of colonies, in particular breeding substrates, average breeding colony size, occupancy, nest failure rates, and numbers of young surviving to a given point in time. It is useful to consider each substrate in turn, which we do below from highest to lowest time-averaged total estimated number of chicks produced for an average colony.

We showed the following for Tricolored Blackbirds: (1) The frequency of occupancy and site extinction (cessation of use) varied substantially among different nesting substrates, but we found no differences in rates of site recolonization by nesting substrate. (2) As predicted by different frequencies of extinction (cessation of use), the duration of occupancy varied among nesting substrates. (3) Reproductive success showed substantial differences among nesting substrates. (4) Statewide average sizes of breeding colonies in different substrates and frequency of occurrence in different substrates (number of sites) changed through time. The pattern was generally with traditional marsh sites being used less frequently and supporting smaller colonies relative to colonies in native nettles and invasive thistles. Himalayan blackberry colonies are fairly typical in size, occupancy and longevity, and occur with a typical frequency. However Hamilton's data indicate that these colonies have a low failure rate and a higher reproductive success and lower rates of nest failure than other breeding substrates (Figure 3). Consequently long-term breeding productivity of an average blackberry site is expected to be high (Figure 4D). This accords with the findings of Cook and Toft [15], who recorded higher reproductive success for nests in Himalayan blackberry than in other substrates. Unfortunately, Himalayan blackberry is a high risk nonnative invasive species [34] and so it cannot be planted as a component of many federally-funded conservation programs and is frequently removed or attempted to be removed [35]. Himalayan blackberry is problematic because of competition with native plant species, reducing soil moisture and as a potential fire hazard [34]. As Cook and Toft [15] point out there is a conflict between this invasive weed and habitat for Tricolored Blackbirds.

Table 8. ANOVA-style results for linear mixed effects model analyses of reproductive success (RS) for both the Hamilton and Meese datasets.

Fixed Effects:	SS	DF	MS	F	p	h^2
Substrate	58.3	4	14.6	31.6	<0.001	0.59
Error	98.8	214	0.46			

The analysis was limited to breeding substrates with at least 5 measurements. Collector identity and year of collection were removed in model simplification and are not reported further. Effect size is given as the proportion of variance explained by explanatory variables, partial eta-squared (h^2) = (SS_{effect})/(SS_{effect}+SS_{error}). Random effects were: Colony identity (intercept) variance = 0.136, standard deviation = 0.368, from 219 observations in 138 groups (colony identities).
doi:10.1371/journal.pone.0096980.t008

Stinging nettle sites had high occupancy, longevity and reproductive success, and low rates of failure. Consequently nettle sites on average have high long-term breeding productivity (Figure 4D). Stinging nettle sites are however infrequent in occurrence (Figure 4A). Previous studies of reproductive success have lacked sufficient data to evaluate nettle sites. Stinging nettles are native and could be planted to provide breeding substrate for Tricolored Blackbirds but require a reliable supply of fresh water before and during the tricolor's breeding season so may be limited as a conservation tool due to water scarcity.

Marsh colonies (cattails and bulrushes) are the most frequent colony type yet are average compared to other colony types in all aspects measured, including occupancy, longevity, size, reproductive success, and rate of nest failure. The lack of any more positive aspects to marsh sites relative to other colony types makes the net breeding productivity of an average site relatively low (Figure 4D), and consequently their conservation value for Tricolored Blackbirds is more limited than blackberry and nettle sites. Cook and Toft [15] found similar results. Tricolored blackbirds prefer marshes containing vegetation that is young, lush, and rapidly growing, and will avoid older cattail and bulrush marshes containing much thatch and many lodged, dead stems. Hence, marsh management consisting of actions designed to remove old, dead stems and encourage regrowth of new vegetation is needed to promote the use of marsh habitats. In most cases, annual burning is required to rejuvenate marshes and to provide the conditions preferred by breeding tricolors. Water levels are also critical to reducing predator access, as raccoons (*Procyon lotor*), the tricolor's most serious predator in freshwater marshes, prefer to wade than to swim, and typically will not cross deep channels around the perimeter of cattail stands. To this end, the management of marshes for Tricolored Blackbirds by private duck clubs is a potentially important component of a comprehensive conservation strategy since Tricolored Blackbirds and a host of wetland-dependent species may benefit from the springtime availability of water.

Cereal grain fields, including triticale, wheat, and mustard (*Brassica* spp.) growing as a weed within such fields, have since the 1980's held by far the largest colonies (Figure 4C) but have relatively low net reproductive success because of a high rate of colony destruction through harvest (Table 12; Figures 3, 4D). Triticale colonies are frequently destroyed through harvest because the crop ripens before the young fledge and farmers harvest their fields when the seed heads reach maturity [14]. The fact that grain field occupancy is low (even replanted sites are frequently not reused; Figure 1A) and reproductive success is moderate means that a more dynamic conservation strategy is needed (and used) for cereal grain crops; temporary large breeding colonies in grain crops are best targeted when they are present. Cook and Toft [15] also found that colonies in triticale crops that were not harvested had relatively high reproductive success (mean RSS = 1.0), but not as high as the larger dataset used here (mean RSS = 1.76; Figure 3B). Overall the findings for triticale crops accord with both the recommendations of the Tricolored Blackbird Working Group [16] and the use of federal funds to encourage farmers to volunteer to delay harvest of triticale crops containing Tricolored Blackbird breeding colonies. It is not clear that a more permanent preservation of repeatedly planted sites are especially valuable for Tricolored Blackbird conservation because they have a low occupancy by breeding colonies through time. While we recognize that birds breeding in farmers' fields contains great inherent risks, given the relatively large number of birds that breed in grain fields adjacent to dairies and the absence of nearby alternative nesting substrates, it is essential as a core component of a comprehensive conservation strategy that all of these colonies be protected until the young have fledged. In the longer term, additional protected breeding substrates must be provided to give birds secure nesting habitats while ensuring the farmer's right to harvest his crop.

Table 9. Parameter values from linear mixed effects model analyses of reproductive success (RS) for both the Hamilton and Meese datasets.

Mean	Blackberry	1.78	0.12	15.2	0.0001
difference in mean	Marsh	−1.16	0.14	−8.25	0.0001
difference in mean	Nettles	−0.10	0.29	−0.34	0.66
difference in mean	Grain fields	−1.32	0.15	−8.46	0.0001
difference in mean	Thistle	−1.19	0.30	−3.93	0.0001

The analysis was limited to breeding substrates with at least 5 measurements. P-values (''pMCMC'') were obtained using Markov-chain Monte Carlo sampling using the function pvals.fnc from R library language [32]. Collector identity and year of collection were removed in model simplification and are not reported further. The mean value of reproductive success is given for marsh habitat, and then other rows of the table give the difference from this value for the groups indicated.
doi:10.1371/journal.pone.0096980.t009

Table 10. ANOVA-style results for linear mixed effects model analyses of reproductive success of nests that were successful in rearing at least one chick to day 8 after first egg hatch (RSS) for the Hamilton dataset.

Fixed Effects:	SS	DF	MS	F	p	h^2
Substrate	5.53	3	1.84	4.56	0.005	0.15
Error	37.6	93	0.40			

The analysis was limited to breeding substrates with at least 5 measurements. Effect size is given as the proportion of variance explained by explanatory variables, partial eta-squared (h^2) = (SS_{effect})/(SS_{effect}+SS_{error}). Random effects were: Colony identity (intercept) variance = 0.006, standard deviation = 0.08, from 97 observations in 74 groups (colony identities).
doi:10.1371/journal.pone.0096980.t010

Colonies in thistle (e.g., bull thistle, *Cirsium vulgare* and milk thistle, *Silybum marianum*) substrates are relatively infrequent but are typical in occupancy, longevity, reproductive success (but data on failure rates are lacking), and size; consequently they have a typical net long-term productivity per site that is similar to that for grain fields despite the much smaller colony size in thistle sites. In one year (2010) the largest known colony was in milk thistle and had an estimated 83000 birds, which also illustrates that year-to-year variation is high. Again there is the problem that both of these plant species are invasive, although the impacts of milk thistle are limited [34]. Hence a conservation strategy preserving sites and maintaining vegetation type would likely be effective for thistle and milk thistle sites, but nettle substrate is both native and more valuable. Lastly, although data were sparse for willow sites, colonies were small and infrequent, making their net breeding productivity relatively low and consequently their conservation value also low.

A question that arises from our analyses is what is the mechanism (or mechanisms) by which nesting substrate influences reproductive success. Meese [5] showed a clear correlation between insect abundance (food) in habitats around nesting colonies and RS of those colonies in the same year, and only colonies with abundant insects were successful at rearing some young. Meese's analysis produced a correlation between ranked values of 0.74, and hence accounted for 54% of the variation in ranked RS values. It is possible that nesting substrates reflect neighborhood insect abundances, although other effects are also possible. In our analyses breeding substrate accounted for 54% of variation in RS (the same as insects in Meese's study [5]). More importantly, breeding substrate accounted for only 15% of variation in RSS (reproductive success of successful nests), which is consistent either with nesting substrate having greater predictive ability for whether nests succeed or fail, rather than in the number of chicks that produced, or with there being a threshold effect such that RS is more likely to become zero in certain breeding substrates. Beedy, and Beedy and Hamilton [9,14] report that the basic requirements for successful breeding are nesting substrates that are protected by virtue of being flooded, or possess thorny or spiny leaves or stems, and that occur in proximity to foraging habitats. Other studies have reported colony failures because of both predation (e.g., [5,9,17,36,37]), loss of standing water in marsh sites (which also may increase predation, (e.g., [38])) harvest of grain crops (above), and habitat destruction (e.g., [39])). Hence we expect that breeding substrate could have a direct role on colonies by reducing rates of predation. Large losses from colonies have been reported due to predation by Black-crowned Night-herons (*Nycticorax nycticorax*), Cattle Egrets (*Bubulcus ibis*), White-faced Ibis (*Plegadis chihi*), Common Ravens (*Corvus corax*), Coyotes (*Canis latrans*) [5,9,17,36,27]. Avian predators can access nests even in flooded habitats, whereas terrestrial predators can more easily access dried out marshes or terrestrial habitats. Thorny and spiny terrestrial habitats and nests sufficiently far above the ground (e.g., 3-m above the ground in willows [9]) may offer some protection from most predators. The degree to which different habitats differ in predation rates needs more systematic study (as also suggested by [9]). In the central coast of California numbers of some predatory herons and egrets have increased since 1991 [40], and although data are sparse for the Central Valley of California (the area containing most Tricolored Blackbirds), some species have increased nationally (see references in [40]). Beyond the obvious effect of harvesting of colonies in grain fields, the relative extent of disturbance in different habitats requires further evaluation. The kinds of effects are exemplified by Meese [39] who reported a Himalayan blackberry colony that was defoliated causing the birds to abandon the site, and two milk thistle colonies that were destroyed by cutting. Weintraub [17] also reported that some more terrestrial sites (Tamarisk and mesquite) were only used when they were flooded, and hence flooding of sites and conditions more generally might affect site at the time of habitat selection, prior to nesting.

Table 11. Parameter values from linear mixed effects model analyses of reproductive success of nests that were successful in rearing at least one chick to day 8 after first egg hatch (RSS) for the Hamilton dataset.

Parameter type	Group	Parameter	SE	t	pMCMC
Mean	Blackberry	2.19	0.12	18.681	0.0001
difference in mean	Marsh	−0.29	0.15	−1.958	0.056
difference in mean	Nettles	0.69	0.34	2.035	0.046
difference in mean	Grain fields	−0.43	0.20	−2.124	0.038

The analysis was limited to breeding substrates with at least 5 measurements. The mean value of RSS is given for marsh habitat, and then other rows of the table give the difference from this value for the groups indicated. P-values (''pMCMC'') were obtained using Markov-chain Monte Carlo sampling using the function pvals.fnc from R library language [32].
doi:10.1371/journal.pone.0096980.t011

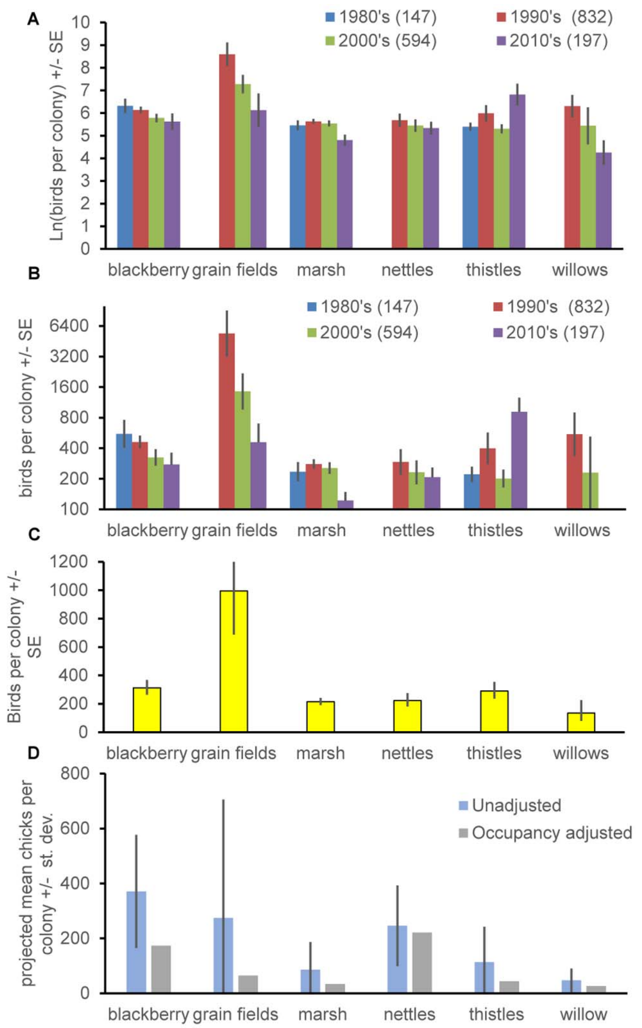

Figure 4. Frequency of colonies, colony size and projected net chick production per colony. A. Proportion of colonies in different substrate types by decade, with total sample sizes in parentheses. **B**. Size of colonies in different substrates by decade (color key same as in a). **C**. Size of recent (2000–2011) colonies. **D** Projected number of chicks produced per colony of average size using reproductive success estimates from Figure 3A and also the same estimates adjusted for the fact that an average site is not occupied in every year (using analyses in Figure 1A). In B and C error bars show +/− 1 SE to facilitate comparison, whereas in D error bars are +/− 1 standard deviation to give an idea of variation. Error bars (standard deviations) are not readily calculable for the occupancy-adjusted projected chicks per colony but likely overlap zero because they represent the summation of at least 3 sources of error (compared to 2 for the other two estimates in D).
doi:10.1371/journal.pone.0096980.g004

Our results in conjunction with Meese's [5] study of food availability in areas surrounding breeding sites indicate that we need to disentangle the effects of nesting substrate, habitats available within the foraging area of breeding Tricolored Blackbirds, and food availability. All three of these things may be correlated or they may be independent. They may also not be mutually exclusive. The problem of analyzing the foraging habitats is made difficult by birds traveling up to 5 to 9km from their nesting sites [5,14,41,42], but as Hamilton and Meese [43] point out, only a small fraction of the total possible area may be suitable foraging habitat. Beedy [9] also suggested investigation of foraging habitat availability near colonies, and habitat selection. Investi-

Table 12. Summary of the differences between colonies in different substrates.

Substrate	Occupancy	Colony longevity	RS	RSS	Frequency of colony failure	Frequency of substrate type	Colony size 2000–2011	Predicted long-term average site productivity
Himalayan blackberry	0	0	+	0	-	0	0	+
Marsh	0	0	0	0	0	+	0	-
Nettles	+	+	+	+	-	-	0	+
Grain fields	-	-	-	0	+	-	+	0
Thistle	0	0	0	0?	0?	0/-	0	0
Willows	0/+?	+?	0?	0?	0?	-	-	-

Colony longevity was inferred from a mixture of survival analyses and extinction analyses. + indicates above average, 0 indicates average, and - indicates below average. A question mark indicates that sample sizes were especially small.
doi:10.1371/journal.pone.0096980.t012

gating habitat selection mechanisms and relative use of different substrates is particularly difficult but it may be that year-to-year variation in the availability of different habitats would provide the best evidence of (correlative) shifts in habitat use, perhaps in conjunction with potential driving variables like rainfall (e.g., [17]).

The suggested conservation strategies for Tricolored Blackbirds of providing alternative habitats and luring birds from grain fields [9] are consistent with our findings of the use and reproduction of different habitats. However, stinging nettle sites seem like the most widely used native habitat type that is productive and may represent the best opportunity for native habitat creation, conservation and restoration. The management of cattail marshes, as the most frequently used marsh type, needs more research linking marsh state to nest success and predation, and may represent a realizable habitat management strategy because protected lands often contain wetland areas. In the short term the voluntary payment of farmers to encourage them to delay harvest of grain crops (triticale) for silage needs to be continued and other strategies of alleviating pressures such as water restrictions on dairy farms that regularly support Tricolored Blackbird merit investigation by management agencies.

The lack of balance between cessation of use ("extinction") and colonization of breeding sites 66% sites/year vs. 21% sites/year reflects that Meese's fieldwork took place during 2005–2011 and that 2007 onwards was a period when reproductive success was chronically low [5]. Population sampling has been more thorough than ever and so these data are unlikely to represent changes in sampling effort. Statewide surveys suggested populations declined by 35% between 2008 and 2011 [44,45], and declines in average colony size are apparent over a longer period in Figure 4B. Both colony sizes and declines in occupancy during 2005–2011 are consistent with a metapopulation that is in steep decline. However, the timespan is short and it remains to be determined whether the 2014 survey (and beyond) will show sustained declines. Neither total abundances nor colony sizes were correlated with rate of (re)colonization of sites or probability of cessation of use of sites for breeding (or reproductive success, RS). In this way the system does have the feedbacks expected of a typical metapopulation [4], which might reflect the species being in decline during 2005–2011: our analyses looked at these factors in conjunction with nesting substrate types so heterogeneity in substrates is unlikely to mask such a pattern.

Future studies should attempt to (1) estimate rates of predation from site to site and between substrate types, which is made complicated by the large number of sites needed; (2) understand whether nesting substrate type is linked to landscape composition and food availability, or whether these are independent drivers of reproductive success; (3) evaluate whether marsh management for Tricolored Blackbirds results in predictable increases in RS, abundance and occupancy; and (4) investigate the potential for habitat creation and restoration involving stinging nettles. There is an urgent need to also ascertain whether the species is continuing in sharp decline across all habitat types and to discover the causes of this decline beyond those identified here. Climate, agricultural changes, and land-use changes all merit investigation as potential causes.

Author Contributions

Conceived and designed the experiments: MH RJM EEG. Performed the experiments: MH RJM EEG. Analyzed the data: MH RJM EEG. Contributed reagents/materials/analysis tools: MH RJM EEG. Wrote the paper: MH RJM EEG.

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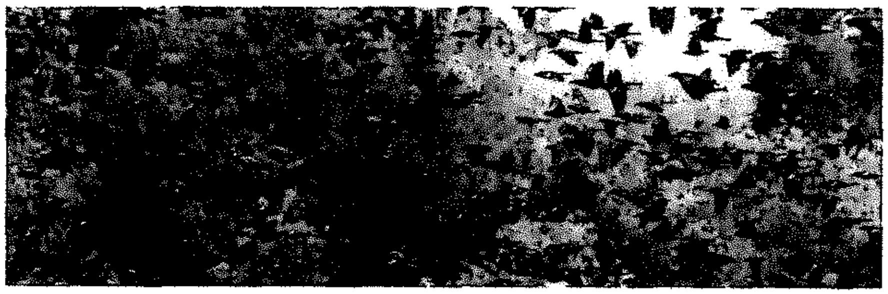
efforts. To that end, we are more broadly marketing this issue to a wider audience with interest in conserving this species.

We hope you enjoy this issue, but more importantly, we hope it spurs you to action on behalf of the Tricolored Blackbird. Your support of the Central Valley Bird Club has helped prepare this issue of the Bulletin. There are many other meaningful contributions that you can make: assisting with ongoing species surveys, financially supporting ongoing conservation efforts, advocating on behalf of the species, publicizing the plight of the species and gaining public support, joining action groups that are identifying and implementing conservation projects... the list goes on. Find a way to help.

Chris Conard (CVBC President) and Daniel A. Airola (CVBC Editor)



Flock of Tricolored Blackbirds. *Photo © Andrew Engilis, Jr.*

Note from Editor:

This issue was made possible through the dedication and hard work by many people. I particularly thank species experts Drs. Robert (Bob) Meese and Edward C. (Ted) Beedy who authored many papers and reviewed others. I also offer thanks to Lowell Young for his encouragement in preparing this volume and his dedication to Tricolored Blackbird conservation. Finally a huge thanks to Layout Editor, Frances Oliver; Photo Editor, Dan Brown; and proof-reader Dan Kopp for their substantial and critical efforts in bring this issue to press.

Daniel A. Airola

Efforts to Assess the Status of the Tricolored Blackbird from 1931 to 2014

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The Tricolored Blackbird (*Agelaius tricolor;* hereafter, also "tricolor"), is unique to California. Among its many salient traits, the tricolor is colonial, and often nests in large groups that place heavy demands upon the local biota. Globally, colonial species are believed to be highly vulnerable (Terborgh 1974), and many have become conservation priorities. The tricolor is among these, as it has over the past century suffered a steep population decline due to reductions in its native breeding and foraging habitats and several other factors (Beedy and Hamilton 1997). More recently, elevated rates of mortality of eggs and chicks have resulted from the destruction of breeding colonies during the harvest of their grain field nesting substrates (Meese 2009), and an unknown number of adults is shot in autumn when in mixed flocks foraging in ripening rice with red-winged and other blackbird species (USDA 2013, Meese unpub. data).

In December 2014 the tricolor was given emergency protection under the California Endangered Species Act as a result of its steep and accelerating population decline (Meese 2014). A petition for listing under the federal Endangered Species Act also has been submitted recently.

It is inherently difficult to assemble enough information on rare species to enable robust evidence-based recovery efforts. In some ways, tricolors pose particular problems in that they breed in a rather small number of large, somewhat ephemeral colonies that, over time, blink on and off across the landscape (Holyoak et al. 2014). As a result, classic random sampling is likely to miss even larger colonies, or to produce population estimates of unknown reliability. On the other hand, the future of the species may rest on the success or failure of a fairly small number of large and conspicuous colonies which are intensively monitored. Thus, the species' unusual biology makes it a unique study subject, but at the same time provides special opportunities to demonstrate that science can greatly improve conservation outcomes.

In order to address these biology-induced sampling problems and to monitor the status of the species, since the 1990's the primary means to estimate the number of tricolors in California has been the triennial Tricolored Blackbird Statewide Survey (Hamilton 2000; Holyoak et al. 2014). The purpose of this report is to review and evaluate efforts to document the status of the species, to contrast prior efforts to those of the past three Tricolored

Blackbird Statewide Surveys, and to examine the most recent trends in abundance and distribution. It excludes consideration of synthetic works (e.g., Graves et al. 2013, Holyoak et al. 2014).

METHODS

I reviewed the scientific literature and other published and unpublished reports beginning with Neff (1937) until mid-2014 to summarize and characterize efforts to determine the status and estimate the size of the Tricolored Blackbird population in California. I used the comprehensive reports of the 2008, 2011, and 2014 Tricolored Blackbird Statewide Surveys, along with the standardized methods and data management support provided by the Tricolored Blackbird Portal (http://tricolor.ice.ucdavis.edu), to compare the results of these three Statewide Surveys and to contrast these with prior efforts to assess the conservation status of the species.

I also present results by "bioregions"—large parts of the state that are relatively ecologically homogeneous and distinct, to assess regional differences (Figure 1). Previous reports (Kelsey 2008, Kyle and Kelsey 2011) have also recognized bioregions, but their boundaries were somewhat different than those recognized here. I divided the state into five bioregions that include the majority of the breeding distribution of the Tricolored Blackbird:

1. Southern California: the entire region south of the Transverse Range; includes southern Kern County, and all of Ventura, Los Angeles, San Bernardino, Orange, Riverside, San Diego, and Imperial counties.
2. San Joaquin Valley: the portions of northern Kern, Tulare, Fresno, Madera, and Stanislaus counties below 100 m elevation and all of Kings, Merced, and San Joaquin counties.
3. Central Coast: Alameda, Santa Clara, Santa Cruz, San Benito, Monterey, San Luis Obispo, and Santa Barbara counties.
4. Central Sierra Foothills: portions of Placer, El Dorado, Amador, Calaveras, and Stanislaus counties between 100-500 m elevation.
5. Sacramento Valley: Sacramento, Yolo, Sutter, Yuba, Colusa, Glenn, and portions of Butte and Tehama counties below 100 m elevation.

The Sacramento Valley is included in the analysis of bioregions although tricolors are itinerant breeders and most birds arrive to breed in this portion of their range only after having first bred in the San Joaquin Valley (Hamilton 1998, Meese unpub. data). Thus, the Statewide Survey, which occurs in the second half of April, provides an estimate of the number of tricolors in the Sacramento Valley at this time but does not provide an estimate of the total number of birds that breed there. Similarly, the Modoc Plateau is not included in this analysis because birds breed in this part of California after April, so are not recorded during the Statewide Survey, the results of which form the data sets upon which this analysis is based.

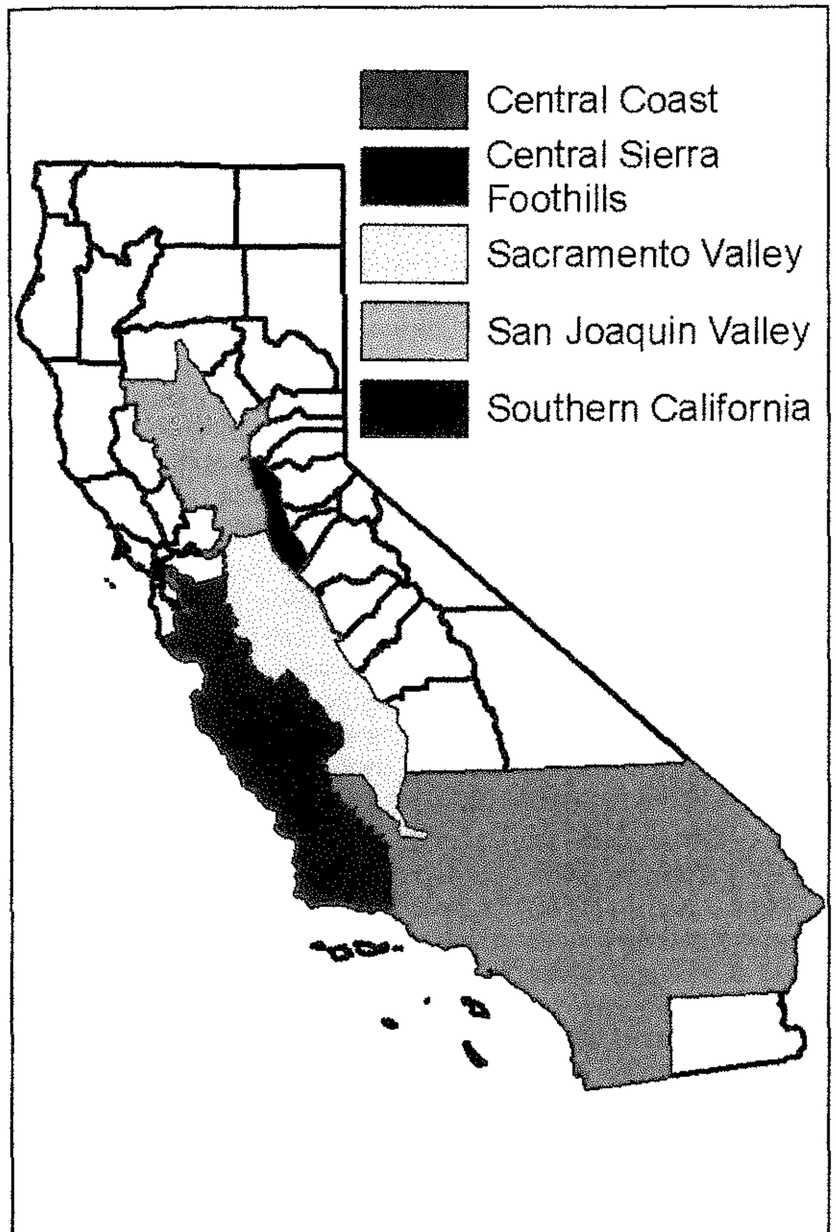

Figure 1. Bioregions used in this paper to discuss Tricolored Blackbird Status in California

RESULTS

Neff (1937) was the first to attempt to assess the status of the Tricolored Blackbird in California. Neff's work was stimulated by anecdotal observations of absences of tricolors from locations where they had previously been common and focused on nest counts in primarily very large colonies during the breeding season and on visual counts of roosting birds at a few locations in the non-breeding season. Neff's (1937) work, conducted from 1931 until 1936, did not attempt to provide a comprehensive survey of the entire range of the species because "such a survey was humanly impossible", and he did not attempt to estimate the number of birds in a brief interval of time. He concluded that the species had likely undergone a serious population decline in response to widespread habitat losses associated with the drainage and filling-in of marshes in the early 20th century. This, he believed, was followed by a population increase due to the development of irrigated agriculture and he found that the species was still quite common in many areas. Although Neff (1937) did not attempt to estimate the total number of birds in California, he provided what he described as a conservative estimate of 491,000 nests within 46 colonies in only eight counties in 1934, which would be about 736,500 birds (assuming that each male breeds, on average, with two females; Beedy and Hamilton 1999).

DeHaven et al. (1975) were the next to attempt to survey a large portion of the tricolor's breeding range. They surveyed much the same region as did Neff and his collaborators over three decades earlier. Their work, conducted from 1969 to 1972, emphasized the Central Valley, although in 1971 they attempted to survey the entire breeding range. Although they, too, studied colonies throughout the breeding season, they concluded that the number of tricolors had declined by at least 50% in the 35 years since Neff's work.

The concept of a Statewide Survey, an effort to estimate the total number of breeding birds in the entire state, was developed by Edward C. (Ted) Beedy and William J. Hamilton III in 1993 (Beedy, pers. comm., Beedy and Hamilton 1997) in response to previous, more limited surveys that suggested an on-going decline in abundance. The Statewide Survey was proposed as a voluntary effort with numerous participants that was centrally coordinated, and conducted within a 3-day interval every three years beginning in 1994. Statewide Surveys were conducted in 1994, 1997, 2000, and 2005, but due to differences in methodology, duration, level of effort, geographic completeness, inadequate data management, and incomplete documentation, the results of these surveys are not directly comparable (Hamilton 2000).

Table 1. Comparison of the first four statewide surveys. Sources: Beedy and Hamilton 1997, Hamilton 2000, EDAW 2005
Sources: Beedy and Hamilton 1997, Hamilton 2000, EDAW 2005

Year	Duration	Participants	Counties Surveyed	Sites Surveyed	Occupied Sites Identified	Birds Observed	Comments
1994	Not reported (3 days?)	68	32	Not reported	28	369,359	follow-up survey results included
1997	Not reported (3 days?)	55	34	Not reported	71	237,928	follow-up survey results included
2000	4 days	81	33	Not reported	71	162,000	pre-survey workshop held
2005	3 days	65	24	Not reported	121	257,802	No report submitted

The Statewide Survey methodology was revised in 2008 by: 1) adding county coordinators to transfer the coordination of the participants from the statewide to the county level, 2) providing training sessions for survey participants, and 3) developing and deploying a web-based Tricolored Blackbird Portal. A level of survey coordination at the county level was added to improve colony detection and geographic completeness by taking greater advantage of local knowledge (Hamilton 2000), and to share the burden of the coordination of a statewide effort among several individuals. In many cases, county coordinators were environmental consultants with extensive local experience with the species and a large pool of qualified persons from which to draw to serve as survey participants.

The Tricolored Blackbird Portal was developed to:

- enhance the management of existing data on colony locations and observations of birds at breeding colonies and in non-breeding aggregations,
- improve communication by providing controlled vocabularies that enabled Portal users to standardize on colony location and nesting substrate names,
- enhance citizen participation by providing online data entry capabilities for records of colony locations and observations of birds (including support for the Statewide Surveys),
- provide reliable natural history information,
- provide access to numerous reports and publications, and
- provide news and links to news reports.

The Portal was developed as a secure, public resource and is password-protected: a user account is required to enter records so as to reduce spam and unwanted spurious records. A small staff of content managers with extensive Tricolored Blackbird and data management experience edits records and assures quality control.

All of the Statewide Surveys since 2008 (i.e. 2008, 2011, and 2014) have used the three levels of coordination (statewide coordinator, county coordinator, participant), are more thoroughly standardized by data entry via the Portal, and are more completely documented by comprehensive reports, so the results of these three surveys are more directly comparable than are those from previous surveys. Table 2 provides a comparison of the results of the three most recent Statewide Surveys.

The results of the three most recent Statewide Surveys showed a rapid decline in abundance, from just under 395,000 birds to 145,000 birds in 6 years, a decline of 63% (Meese 2014). The rate of decline appears to be increasing: from 2008 to 2011 the number of tricolors dropped by 35%, from 395,000 to 258,000 birds (Kyle and Kelsey 2011), but from 2011 to 2014 the number of birds dropped by 44%, from 258,000 to 145,000 birds (Figure 2).

Table 2. Comparison of 2008, 2011, and 2014 Statewide Surveys. Sources: Kelsey 2008, Kyle and Kelsey 2011, Meese 2014

Year	Duration (days)	Participants	Counties Surveyed	Sites Surveyed	Occupied Sites Identified	Statewide Population Estimate
2008	3	155	38	361	155	394,858
2011	3	100	29	608	138	258,000
2014	3	143	41	802	143	145,000

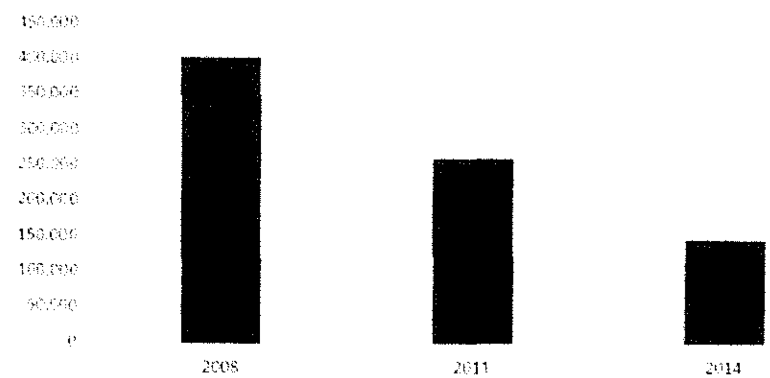

Figure 2. Estimates of the number of Tricolored Blackbirds in California in 2008, 2011, and 2014.

The decline in the statewide estimate of the number of birds occurred despite a rapid increase in knowledge of where the birds breed, as data entry via the Tricolored Blackbird Portal has allowed 77 different Portal users to enter 249 new colony location records since 2008 (Figure 3).

The 2014 Statewide Survey was the most comprehensive: 802 known locations were surveyed versus only 361 locations surveyed in 2008 (Table 2). Hence, the recorded decline cannot be attributed to a decline in the thoroughness of the surveys.

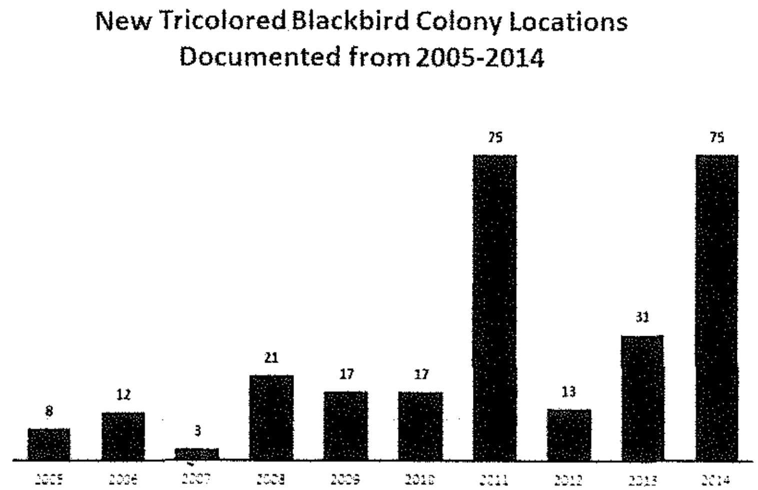

Figure 3. Number of previously unreported Tricolored Blackbird colony locations reported each year from 2005-2014.

Associated with the decline in the number of birds was a dramatic decline in the sizes of the largest colonies (Figure 4).

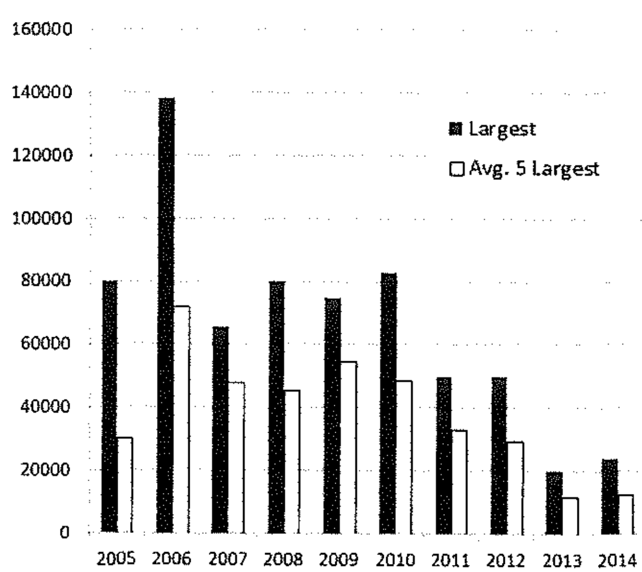

Figure 4. Ten year trend in the sizes of the largest Tricolored Blackbird colonies and averages of the five largest colonies.

The rate and intensity of the decline between 2008 and 2014 varied among bioregions. The Central Coast had the greatest proportionate decline, dropping 91%, from 7,014 birds in 2008 to 652 birds in 2014. The San Joaquin Valley had the second highest proportionate decline, dropping 78% from 340,703 birds in 2008 to 73,482 birds in 2014. The number of birds in southern California increased by 126%, from 5,487 birds in 2008 to 12,386 birds in 2014, due primarily to a single large colony of 5,000 breeding birds in Los Angeles County (Meese 2014). The number of birds in the Central Sierra Foothills also increased, from 22,586 birds in 2008 to 28,281 birds in 2014. Figure 5 summarizes the results for the three most recent Statewide Surveys by bioregion.

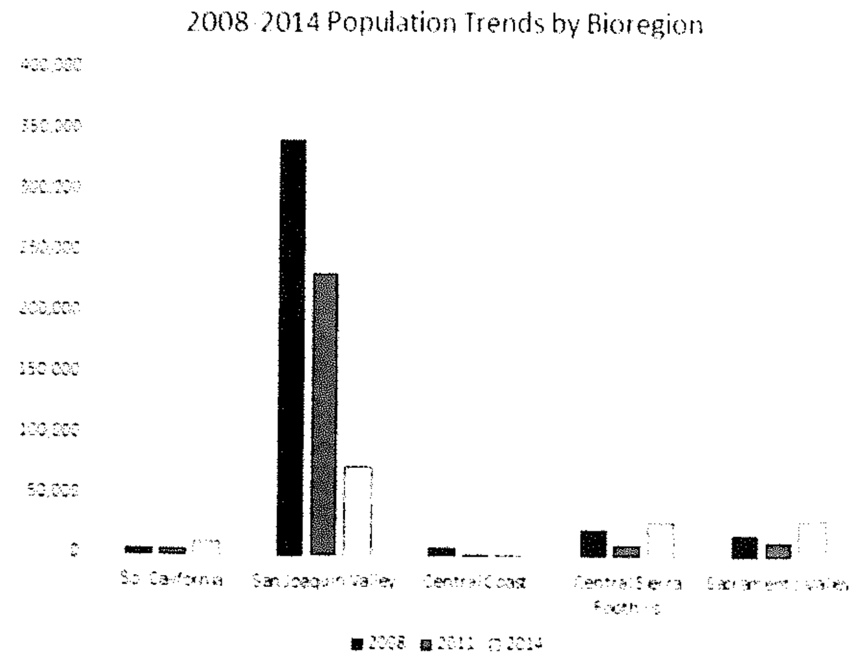

Figure 5. Results of 2008, 2011, and 2014 Statewide Surveys by Bioregion.

DISCUSSION

Early efforts to determine the status of the Tricolored Blackbird depended upon the work of a small number of individuals who tried to survey an immense geographic area and, due to logistical and time constraints, had to focus on locations concentrated in the Sacramento Valley (Neff 1937, DeHaven et al. 1975). Neither Neff (1937) nor DeHaven et al. (1975) attempted to estimate the statewide population of the species but rather attempted to survey breeding birds during the entire breeding season. DeHaven et al. (1975) surveyed the region studied by Neff (1937) to try to determine whether the species had changed in abundance in this portion of its range. They found far fewer colonies and far fewer birds at the largest colonies than did Neff (1937) and concluded that the number of tricolors in the Sacramento Valley had declined by more than 50% in about 35 years.

Efforts to estimate the statewide population of tricolors began in 1994 with work coordinated by Beedy and Hamilton (1997) and continue to this day. Unlike previous efforts to assess the status of the species, Statewide Surveys were conducted in 3-day intervals, from Friday to Sunday, in late April. Non-breeding birds tend to be highly mobile and difficult to find and thus to count, so the Statewide Survey was designed to be conducted in the second half of April, when the maximum number of birds are breeding (Beedy and Hamilton 1999), and are thus more reliably found and easier to count. Conducting a Statewide Survey during a 3-day interval minimizes the risk of double-counting birds that have moved following first breeding attempts (Hamilton 1998). Increasing the number of persons surveying allows a much larger geographical area to be covered and enables a statewide estimate of the number of birds.

Although the 1994 Statewide Survey included only 32 counties and found only 28 occupied sites, the estimate of the number of birds seen exceed 369,000 (Hamilton et al. 1995). The 2014 Statewide Survey covered 41 counties and found birds at 143 locations yet the estimate of the number of birds in California dropped to 145,000 (Meese 2014). Thus, despite substantial increases in geographical coverage and in knowledge of where the birds nest, the estimate of the number of birds seen dropped by 61%. In the 2008-2014 interval, when the Statewide Surveys were far more directly comparable due to more standardized methodology, the estimate of the number of tricolors dropped by 63%, from 395,000 to 145,000. Unfortunately, given the differences in methods, level of effort, data management, and data documentation, it is not possible to directly compare the results of the Statewide Surveys from 1994 to those of 2014, but the small number of colonies identified and the relatively large number of birds observed in 1994 compared to 2014 suggests a serious statewide reduction in abundance during this 20 year interval, and that the extent of the decline would be greater than that estimated if the 1994 survey had been as complete as was that of 2014.

The number of birds seen during the three most recent Statewide Surveys differed greatly by bioregion, with the largest number of birds seen in all three surveys concentrated in the San Joaquin Valley (Figure 5), where the majority of breeding birds have been seen since the 1980s (Hamilton et al. 1995). A comparable survey of breeding birds in the Sacramento Valley would best occur in early June, when most of the birds have finished breeding in the San Joaquin Valley and moved north to breed again (Hamilton 1998, Beedy and Hamilton 1999, Meese unpub. data). As the tricolors that breed in the Sacramento Valley are in most cases the same birds that bred earlier in the San Joaquin Valley (Hamilton 1998, Meese unpub. data), any reduction in abundance documented in April in the San Joaquin Valley would be expected to be mirrored by a reduction in abundance of breeding birds in the Sacramento Valley the following June.

Because the vast majority of breeding birds occur in the San Joaquin Valley, the sharp drop in abundance documented there is of particular concern, as efforts to restore the species will depend disproportionately upon the results of breeding efforts at the largest colonies. Recent research has shown that reproductive success is positively correlated with both colony size and insect abundance (Meese 2013), and the results of the three most recent Statewide Surveys showed a sharp drop in total abundance and size of the largest colonies. This period coincided with a period of chronically low reproductive success (Meese 2013). A lack of insects along with the destruction of breeding colonies adjacent to dairies by the harvest of their nesting substrates (Meese 2009) are believed to be the two most important causes for the recent population decline.

There are several reasons why insect abundances may be insufficient to support breeding by the colonial and insectivorous Tricolored Blackbird. The widespread and on-going conversion of native habitats to dairies, orchards, vineyards, rice, and other forms of agriculture (Beedy and Hamilton 1997) and the use of effective and persistent insecticides (Hallmann et al. 2014) may have created unsuitable breeding conditions in much of the core area of the species' range. The relatively small number of birds that have recently bred outside of the San Joaquin Valley is insufficient to sustain a population of 700,000 birds, the suggested population target for the recovery of the species (Meese et.al. 2015a). The apparent unsuitability of much of the San Joaquin Valley to support breeding by the species suggests that future conservation actions will have to occur in strategically chosen areas of the Central Valley that have previously or may be managed to support breeding by relatively large numbers of birds. The conservation effort will require both secure, permanent nesting habitats surrounded by secure, productive, foraging habitats that may provide the insect abundance that is associated with relatively high reproductive success (Meese 2013, Meese et al. 2015a). The rapid decline in the sizes of the largest colonies (Figure 4) complicates conservation planning and reduces the options available to stem the decline because even effective conservation actions will be expected to benefit a smaller number of breeding birds.

The conservation of breeding colonies in grain fields adjacent to dairies may be ensured by the recent listing of the Tricolored Blackbird as endangered under the California Endangered Species Act (CESA). Any loss of Tricolored Blackbird eggs or nestlings would be considered "take" and is prohibited under CESA, except with explicit permit approval. Recent voluntary efforts to conserve Tricolored Blackbird breeding colonies adjacent to dairies, by compensating farmers for their costs associated with delaying the harvest of their occupied grain fields, have been only partially successful (e.g., Meese 2009, Meese 2014). Effectively conserving the efforts of all breeding birds, and especially the largest colonies, which are usually situated in grain fields (Beedy and Hamilton 1999, Kelsey 2008), will be essential if the species is to recover. A far more robust education and outreach component must be developed and implemented with industry participation (see Arthur 2015), and intensive surveys and monitoring of "silage colonies" must occur annually. These silage colony conservation measures, however, are temporary emergency reactions to an on-going conflict, and a permanent solution will require the provision of alternative nesting substrates in the San Joaquin Valley and southern California that create safe, secure breeding conditions.

The triennial Tricolored Blackbird Statewide Survey has for 20 years played a prominent role in efforts to monitor the health of tricolors in California. Recent improvements in methodology and the addition of the Tricolored Blackbird Portal have rapidly increased our knowledge of where the birds breed by providing a mechanism for concerned citizens to become actively engaged in research and monitoring efforts. The resulting increase in the number of persons looking for and reporting breeding colony locations and observations of (occupied and unoccupied) breeding colony locations has aided efforts to monitor the health of the species.

The Tricolored Blackbird is increasingly conservation-dependent, and future monitoring efforts should expand beyond a triennial statewide population estimate to include the: 1) annual monitoring of the results of breeding efforts in a variety of habitats and bioregions, 2) effects of relative insect abundance on reproductive success, and 3) results of specific conservation actions. A useful addition to the triennial Statewide Survey would be an annual effort to estimate the population size through a statistically valid sample (see Meese et al. 2015b). This monitoring tool would provide an annual population estimate with a much smaller number of volunteers and require surveys of only a sample of the total number of colony locations each year. An annual sample survey would provide an additional means to monitor the health of the population and supplement more intensive efforts to monitor the results of tricolor breeding, thereby helping to more thoroughly document the status of California's blackbird.

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Sampling to Estimate Population Size and Detect Trends in Tricolored Blackbirds

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The Tricolored Blackbird (*Agelaius tricolor*) is a medium-sized passerine that nests in the largest colonies of any North American landbird since the extinction of the passenger pigeon (*Ectopistes migratorius*) over 100 years ago (Beedy and Hamilton 1999). The species has a restricted range that occurs almost exclusively within California, with only a few hundred birds scattered in small groups in Oregon, Washington, Nevada, and northwestern Baja California, Mexico (Beedy and Hamilton 1999). Tricolored Blackbirds are itinerant breeders (i.e., breed more than once per year in different locations) and use a wide variety of nesting substrates (Hamilton 1998), many of which are ephemeral. They are also insect dependent during the breeding season, and reproductive success is strongly correlated with relative insect abundance (Meese 2013). Researchers have noted for decades that Tricolored Blackbird's insect prey are highly variable in space and time; Payne (1969), for example, described the species as a grasshopper follower because they are preferred food items, and high grasshopper abundance is often associated with high reproductive success (Payne 1969, Meese 2013). Thus, the species' basic reproductive strategy is tied to rather infrequent periods of relatively high insect abundance in some locations followed by much longer periods of range -wide relatively low insect abundance and poor reproductive success. Of course, anthropogenic factors such as habitat loss and insecticide use may be at least partly responsible for these patterns (Hallman et al. 2014, Airola et al. 2014).

The Tricolored Blackbird was formerly considered to be one of the most abundant land birds in California (Beedy and Hamilton 1999), and it is likely that 2-3 million birds remained into the 1930s (estimated by extrapolation of Neff 1937, see Meese 2015). The alarming decline in abundance, especially in the past decade, to only 145,000 birds in 2014 (Meese 2014) led to an emergency listing of the species as endangered under the California Endangered Species Act (CESA) in December 2014 (State of California 2014).