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EFFECTIVENESS OF PUBLIC–PRIVATE EFFORTS TO CONSERVE TRICOLORED BLACKBIRD COLONIES ON AGRICULTURAL LANDS IN THE SAN JOAQUIN VALLEY, CALIFORNIA

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ABSTRACT: Since the early 1990s when much of the population of the Tricolored Blackbird (*Agelaius tricolor*) began nesting in fields of triticale grown for dairy silage in the San Joaquin Valley, many colonies have been destroyed inadvertently during harvest. After previous inconsistent efforts, in 2015 a Regional Conservation Partnership Program brought the dairy industry, Natural Resource Conservation Service, Audubon California, California Department of Fish and Wildlife, and other partners together in an effort to stem the losses. The program located colonies and compensated farmers for crop value lost when the harvest was delayed until after the blackbirds fledged and encouraged creation of alternative nesting habitat to attract nesting birds away from agricultural fields. Before 2015, data on the numbers of colonies in silage fields, and on the blackbirds' productivity conserved and lost, are complete only for 2005–2009, when only 43% of colonies encompassing 60% of the monitored nestings avoided destruction. From 2015 to 2022, 93% of colonies representing 96% of nesting attempts were conserved, and the number of birds nesting in silage increased by as much as 100,000. The program's success resulted from the adequacy of federal funding, protection provided by the species' listing as endangered by the state of California, and effective communications and cooperation among the partners and within the dairy industry. Protection of colonies in silage fields since 2015 likely contributed to the substantial increase in the numbers of birds nesting in this habitat and perhaps to an increase in California's Tricolored Blackbird population as a whole. Continued effort is needed to achieve the species' recovery.

The Tricolored Blackbird (*Agelaius tricolor*) is a colonial-nesting species nearly endemic to California. Its long-term decline (Clipperton 2018)

resulted in its designation as threatened under the California Endangered Species Act in 2019 (Beedy et al. 2018). The decline is attributed initially to conversion of large areas of wetlands to agriculture (ibid.), more recently compounded by conversion of grasslands and favorable agricultural crops to orchards, vineyards, and urban development (Cook and Toft 2005, Graves et al. 2013, Airola et al. 2018a, b, 2023), reduction of insect prey to increased use of neonicotinoid insecticides (Meese 2013, 2014, 2015b, Clipperton 2018, Graves et al. 2022), aridification (Erickson et al. 2021), and destruction of breeding colonies during agricultural harvest (Meese 2014, 2015, Beedy et al. 2018, Clipperton 2018).

The Tricolored Blackbird's breeding population in California has been assessed through the triennial statewide survey (Meese 2022). The surveys of 2008, 2011, 2014, 2017, and 2022 are considered sufficiently complete and standardized to be a basis adequate for assessing population trends. The statewide survey showed a 63% decline from 395,000 in 2008 to 145,000 in 2014, then increased over the next two surveys to 218,000 in 2022 (ibid.). Independent analyses estimated a population decline of 5–6% annually and by 40% from 2008 to 2017 (Meehan et al. 2018, Robinson et al. 2018).

In apparent response to habitat loss, in recent decades tricolors have adapted to nest in several anthropogenic habitats. Much of the remaining population now nests in non-native Himalayan blackberry (*Rubus armeniacus*) and smaller wetlands in grassland-dominated regions (Cook and Toft 2005, Airola et al. 2018b, Airola 2021). A high proportion of the population also now nests in agricultural fields in the San Joaquin Valley (Meese 2009, Kyle and Kelsey 2011, Clipperton 2018; see Results).

Triticale, a hybrid of wheat and rye grown as a silage crop for dairies, is currently the main agricultural crop in which the tricolor nests (Graves et al. 2013, Clipperton 2018). Its use was first noted in 1989 (Beedy et al. 1991), and by large colonies in the early 1990s (Hamilton et al. 1995, Meese 2009). Triticale grown for silage must be harvested at early maturation when its moisture and energy content is high and fiber level is low, as it quickly loses its forage value (Mayo and Lozano del Rio 2004). Harvest often coincides with the tricolor's incubation and nestling stages so often results in loss of the reproductive effort of an entire colony (Beedy et al. 2018).

The tricolor's use of triticale fields has prompted concerns over the species' conservation. Losses of large colonies have been reported since the 1990s when dairy operations in the Central Valley increased (Hamilton et al. 1995, Kyle and Kelsey 2011, Clipperton 2018). Initially, Hamilton et al. (1995:i) suggested that losses during triticale harvest were inconsequential because the tricolor's population was limited by available habitat and "protective measures such as intervention in agricultural operations will have no lasting effect upon the populations, and such measures may be counterproductive… [by] inducing increased problems at dairies and elsewhere." They recommended creating new habitat to support a larger population and finding ways to protect colony sites on private lands because most habitat suitable for the species is privately owned. Notwithstanding some localized creation of habitat for the blackbird in recent decades (see Results), the net extent of habitat has continued to decline through conversion of grasslands and suitable open field crops, such as hay and alfalfa, to unsuitable orchards and vineyards and to

residential and commercial development (Cook and Toft 2005, Cameron et al. 2014, Beedy et al. 2018, Airola et al. 2023).

Efforts to protect colonies in silage began as early as 1992 with establishment of a conservation framework that included colony surveys, voluntary landowner agreements, compensation for crop value lost when harvest was delayed until after fledging, and in some cases payment of full market value to buy the crop occupied by a blackbird colony (Meese 2009). Before 2015 conservation efforts and monitoring were often sporadic because of inadequate and inconsistent funding and lack of legal incentives for protection, resulting in recorded and presumably unreported cases of colony destruction (Kelsey 2008). Surveys, and to a lesser degree conservation efforts, were more comprehensive from 2005 to 2009 (Meese 2009) but then were sporadic and not well reported again from 2010 to 2015.

Following continued losses of tricolor colonies to harvest of triticale, in 2015 the Natural Resources Conservation Service (NRCS) awarded $1.1 million under its new Regional Conservation Partnership Program to a partnership consisting of Dairy Cares, Audubon California, the California Farm Bureau Federation, Sustainable Conservation, and Western United Dairies (Arthur 2015, Audubon California 2020). The grant was awarded to protect, restore, and enhance tricolor habitat on San Joaquin Valley agricultural lands over five years. The conservation plan adopted by the 16-member Tricolored Blackbird Working Group (2007) identified the partnership program's goals: to compensate producers for crop value lost by delaying harvest to protect nesting blackbirds, to restore and enhance wetlands and private farmlands to provide safe alternative nesting sites, to develop crop insurance or silage banks as a long-term substitute for federal compensation programs, and to communicate effectively among partners and within the farm community the importance of protecting the tricolor and the industry's role in saving the species. Partners contributed matching services in kind and cash that raised the value of the program's funding to nearly $2 million. The California Department of Fish and Wildlife (CalDFW), the trustee agency, separately initiated efforts to identify agricultural colonies and monitor their numbers and fates, and it contributed toward funds to reimburse landowners for delaying their harvests.

Conserving the tricolor has required developing and applying new and innovative approaches to foster collaboration among resource-management agencies, nonprofit groups, and private entities. Describing the Regional Conservation Partnership Program and evaluating its effectiveness, along with that of other programs aimed at the tricolor's conservation, may have broader implications for other species, geographic regions, and land uses. We describe the various elements of the conservation program, evaluate its effectiveness at reducing the disruption and loss of colonies on farms, and discuss the potential contribution of the program to the tricolor's recovery.

This assessment is limited to the San Joaquin Valley, which supports the largest number of silage-nesting tricolors in California (Clipperton 2018); it does not include those protected on agricultural lands in San Luis Obispo and San Benito counties and southern California because of differences in completeness of conservation efforts and their evaluation.

METHODS

Study Area

The arid southern San Joaquin Valley within Stanislaus, Fresno, Merced, Mariposa, Madera, Kern, Kings, and Tulare counties covers 25,000 km^2 devoted largely to irrigated agriculture. The valley supports a large dairy industry (MacMullen 2007, Matthews and Sumner 2019) and extensive areas of almonds, grapes, alfalfa, wheat, pistachios, tomatoes, and other crops (https://www.csustan.edu/sites/default/files/groups/Geography/Images/sjvagjb.pdf). Lands managed for wildlife conservation include the San Luis, Merced, Kern, and Pixley national wildlife refuges, several state parks, wildlife management areas, and reserves, and private duck clubs.

Data Acquisition

We compiled available information from prior to 2015 on the tricolor's use of silage fields in the San Joaquin Valley and the numbers of colonies and birds whose nesting efforts were conserved or lost to agricultural harvest from published articles, unpublished reports, and several personal sources (Table 1). We use *conserved* for active colonies that were not destroyed by harvesting, but this does not imply that the colony was successful, as undisturbed colonies regularly failed because of predation, unfavorable weather, or inadequate food supply (e.g., Meese 2008, 2011, 2013). Most of these estimates were made by highly experienced observers, except those compiled from 1991 to 2004 by Belensky and Bond (2014), for which some of the primary sources could not be determined. Therefore, we used that source only where other reporting was unavailable.

From 2015 to 2022, the staff of Audubon California, CalDFW, and contractor Colibri surveyed two or three times per week from mid-March to early June, mainly from public roads (Colibri 2017, 2018, 2020, 2021, Castañeda unpubl. data). Surveyed areas included previously used colony sites (https://tricolor.ice.ucdavis.edu/) and suitable areas in and around silage fields where large concentrations or flights of birds apparently commuting to foraging habitat suggested a colony. Once located, colonies were resurveyed regularly according to Meese's (2017b) guidelines for censusing, identifying nesting stages, and ascertaining fates. Colony sizes were generally estimated during the settlement and nestling stages, when most birds in the colony are visible (Meese 2017b). Estimates were based on a combination of direct counts, extrapolating from typical nest densities to the area occupied, and counting nests along a transect after breeding.

Several issues impair the accuracy and precision of counts of the Tricolored Blackbird. Counting colonies is straightforward because their nesting pairs are highly concentrated and each colony is widely separated from others. Estimating numbers of birds at silage colonies, however, is challenging for several reasons. The birds may abandon a site, or numbers may fluctuate as nesting proceeds (Beedy et al. 2018). Some estimates must be made at a distance because of lack of access. Even with good access, a count's accuracy is confounded by the colony's size and dynamic nature, with many birds traveling unknown distances in multiple directions to forage. Also, the birds'

Table 1 Numbers of Colonies and Numbers of Tricolored Blackbirds Breeding in San Joaquin Valley Silage Fields, 1993–2022

	Total		Conserved		Lost to harvest		Fate unknown		
Year[a]	Colonies	Breeding birds	Colonies	Breeding birds	Colonies	Breeding birds	Colonies	Breeding birds	Sources[b]
1993		63,000		48,000		15,000			1
1994	6	251,600	3	153,000	2	66,600	1	32,000	2, 3, 4
1995		100,000				100,000			4, 5
1996		100,000				100,000			4
1997		92,500				92,500			4
1998		125,000	1	45,000		80,000			4, 6
1999			1	35,000	1	14,000			1,3, 4
2000	7	52,000	2	37,500	4	9,500	1	5000	1, 7
2003	2	80,000	0.4	16,000	1.6	64,000			8
2004					2	50,000			9, 10
Total[c]	9	864,100	7.4	350,500	10.6	591,600	2	37,000	
Average[c]	3.0	108,013	1.5	55,750	2.1	59,160	1.0	18,500	
2005	4	142,000	2	122,000	2	20,000			9, 10
2006	8	363,800	3	208,800	5	155,000			9. 10
2007	7	136,750	1	30,000	6	106,750			9
2008	10	300,000	4	160,000	6	140,000			9, 13
2009	8	199,500	7	143,500	1	20,000	2	36,000	9
Total	37	1,142,050	17	664,300	20	441,750	2	36,000	
Average	7.8	228,410	3.4	132,860	4	88,350	0.4	7,200	
2010					0	0			14
2011		170,000		110,000	3	60,000			4, 15, 16
2012			4	102500	1+				17, 18
2013			6	52000	1+				17, 18, 19
2014	9	110,000	4	60,000	≥2	50,000+			17, 18, 20
Total	9	280,000	14	324,500	7	110,000	0	0	
Average[c]	9	140,000	4.7	81,125	1.5	55,000			
2015	7	75,000	7	75,000	0.5	0			18, 20, 21
2016	10	71,500	10	71,500	0	0			22, 23
2017	9	79,000	8	64,000	1	15,000			24, 25
2018	11	119,000	11	119,000	0	0			14, 26
2019	16	169,000	14	148,000	1	21,000			23
2020	16	165,000	16	165,000	0	0			27
2021	14	178,100	11	176,000	2	2,100	1		28, 29
2022	14	137,500+	13	137,500	1	No est.			19, 23
Total	97	994,100	91	956,000	5	38,100	1		
Average	12.1	124,262	11.4	119,500	0.6	5,443	0.1		

[a]No data available for 2001 and 2002.

[b]Sources: [1]Hamilton 2000, [2]Hamilton et al. 1995, [3]Kelsey 2008, [4]Belensky and Bond 2014,[5]Beedy and Hamilton 1997, [6]Hamilton et al. 1999, [7]DeHaven 2000,[8]Cook and Toft 2005, [9]Meese 2009, [10]Hamilton and Meese 2006,[11]Meese 2006, [12]Meese 2007, [13]Meese 2008, [14]Clipperton 2018, [15]Meese 2011, [16]Kyle and Kelsey 2011, [17]J. Baum unpubl. data, [18]S. Frazer unpubl. data, [19]N. Clipperton unpubl. data, [20]Meese 2014, [21]Meese 2015b, [22]Meese 2016, [23]X. Castañeda unpubl. data, [24]Colibri 2017, [25]Meese 2017c, [26]Colibri 2018, [27]Colibri 2020, [28]Colibri 2021, [29]J. Davis unpubl. data.

[c]Total numbers and averages do not always add as expected because of incomplete data.

activity and thus detectability vary substantially by stage of the nesting cycle. As a result, even estimates by seasoned observers can vary substantially.

To maximize the surveys' accuracy, we used highly experienced surveyors who followed statewide survey guidelines (Meese 2017b), estimating colony sizes weekly during the settlement and nestling stages when most birds are visible, and tracking colonies throughout the nesting period to detect colony abandonment or reduction or augmentation of numbers. Multiple estimation methods were used, including direct counts, applying typical nesting densities to the occupied colony area, and post-breeding nest-transect sampling. Numbers reported by different surveyors varied (generally by <20%). NRCS–Audubon California biologists often had better access to colony sites than did CalDFW contractors and thus made better estimates (Colibri 2020). NRCS reported a range of estimates for each site. For annual totals, we generally used averages of the estimates by NRCS, and those by CalDFW contractors where they were reported to be more complete.

Conservation Program Actions

Legal and regulatory protection. Several legal and regulatory measures contributed importantly to the conservation program. Prior to 2017, the Migratory Bird Treaty Act protected the tricolor from "take" (i.e., injury, killing) in agricultural fields (USFWS 2019), and the threat of enforcement by the USFWS was an incentive for some landowners to work with conservation agencies to delay harvest until nesting was completed. This protection was only partially effective, as many colonies were destroyed during this period (see Results), in some cases despite the USFWS being notified. The legislation's protection was eliminated in 2017 when the Department of Interior's solicitor general issued an opinion that incidental take of migratory birds did not constitute a violation of the Migratory Bird Treaty Act, which was codified into regulation in early 2021. Shortly after the change in presidential administration on 20 January 2021, the USFWS announced its intention to revoke the regulation and reestablish protections against incidental take in October 2021 (50 CFR 10; 86 FR 54642:54642-54656).

An emergency designation of the tricolor as a candidate under the California Endangered Species Act in December 2014 conferred state prohibitions on "take," leading CalDFW (2015) to issue guidance for protecting colonies. But the listing was not adopted after the one-year candidacy, and protections lapsed in June 2015 (Clipperton 2018). Then in 2019 the species was listed as threatened under the California Endangered Species Act, increasing incentives for landowners' participation and continued federal and state funding. The California act's provisions prohibiting unauthorized take also led to development of a Local Voluntary Program under which CalDFW authorized the California Farm Bureau Federation, acting as program administrator, for incidental take under Fish and Game Code Article 3.5 (section 2086 et seq.). This authorization protected dairy producers from liability due to inadvertent take of tricolors while following best management practices, which increased landowners' trust in other program partners and promoted their participation in conservation efforts.

On-the-ground conservation efforts. The conservation program encompassed several distinct components and actions taken to protect nesting

colonies. Audubon California and NRCS staff coordinated in conducting surveys to detect and monitor tricolor colonies. Dairy-industry partners contacted affected landowners to inform them of legal requirements and protection measures. Audubon or NRCS staff then enrolled landowners in the conservation program and provided technical assistance. Conservation program funding came from the NRCS's Regional Conservation Partnership Program and Declining Species Initiative, mostly in-kind contributions from Audubon California, and funding from CalDFW and the U.S. Fish and Wildlife Service (USFWS) via direct payments to landowners and or existing habitat-management programs. CalDFW initiated a simultaneous program to fulfill its trustee responsibilities by (1) detecting colonies and monitoring agricultural activities and conservation actions, (2) coordinating conservation efforts and encouraging enrollment in the NRCS program, (3) paying portions of crop reimbursements, and (4) providing incentives to private landowners to create semi-permanent wetlands as breeding habitat away from agricultural lands.

Under the colony-response plan developed by the Tricolored Blackbird Working Group (Meese 2011, 2015b), each dairy-farm owner with a tricolor colony was contacted by John Labandeira, a retiree from Western United Dairies who understood the tricolor's ecology and had credibility with the dairy community. He informed them of the legal requirements and protection measures and helped identify compensation to be paid by the NRCS should the harvest need to be delayed until after the blackbirds fledged. Protection measures included applying a buffer zone 15 m wide around each colony and seasonal restrictions recommended by CalDFW (2015). Producers provided a target date for silage harvest, which they adjusted over time as the crop grew. If a harvest would conflict with nesting, the partners informed the landowner of the area where harvest was to be delayed. Continued monitoring verified that protection remained in place and projected the date of the fledglings' dispersal, when harvest could proceed.

Payments to landowners came from the NRCS's Regional Conservation Partnership Program and Declining Species Initiative, CalDFW, and the U. S. Fish and Wildlife Service (USFWS). Reimbursement for lost crop value was calculated with an equation devised by the NRCS that included estimates of forgone income, labor, water management, and materials, the result of which was then multiplied by the acreage for which harvest was delayed. Reimbursements were generally less than the full value of the crop loss, which placed some residual financial burden on landowners who hosted nesting colonies (Colibri 2021).

Publicity about the effort comprised information and videos posted on the Audubon California and Dairy Cares web sites, communications with local Audubon chapters and members, and media press releases. These communications were intended to educate the public on the tricolor's importance and the positive role that dairies, the NRCS, and conservation groups were playing in its conservation, thereby promoting and sustaining public and government agencies' support for conservation funding and programs. Communications highlighting the cooperation of the dairy industry and individual dairy producers to help maintain their support.

Success of Colony Protection and Landowner Reimbursement

We evaluated the conservation program's success from 2015 to 2022 by comparing the numbers of colonies and breeding individuals in silage colonies that were conserved or lost to harvest during this period to the results of previous years since 1993. We focused on comparing 2015–2021 results to those of 2005–2009 (Meese 2009), the only earlier period for which comprehensive information was available.

To evaluate the program's cost-effectiveness, we compiled compensation paid to producers to delay harvest over three periods: 2005–2009, 2012–2014, and 2015–2021. We then calculated the average reimbursement cost per colony and per breeding bird over these periods. Notably, the costs for administration, monitoring, and landowner outreach (roughly estimated as 50% of direct reimbursement costs, Castañeda unpubl. data) and funds spent on other aspects of conservation (i.e., creation of alternative nesting habitat, development of crop insurance and silage banks) were not incorporated into this evaluation. We evaluated the protection efforts' potential contribution to the tricolor's 2015–2021 population by the change in the size of the population nesting in silage fields and by comparison with trends in the statewide population recorded during the statewide surveys conducted since 2008 (Meese 2022).

RESULTS

Effectiveness of the Colony-Protection Effort

Numbers of colonies and Tricolored Blackbirds breeding in agricultural fields in the San Joaquin Valley since 1993 are listed in Table 1, along with the numbers conserved and destroyed.

1992–2004. Colony monitoring in dairy silage fields was inconsistent and incomplete over this period, except in 1994, 2000, and 2003 (Table 1). Annual losses reported during this period range from one to four colonies supporting 15,000–100,000 nesting birds, while one to three colonies supporting 16,000–153,000 birds were conserved annually. As monitoring and reporting were fragmentary, additional colonies and breeding birds likely were lost and not detected or reported. During the three years of apparently complete reporting, an average of two colonies supporting nearly 69,000 adults (53% of those nesting in silage) were conserved, and three colonies supporting nearly 47,000 adults (36%) were lost to harvest. The fates of the remaining colonies and birds were not determined. Thus during this period some larger colonies were saved, but losses were substantial.

2005–2009. During this period with careful documentation (Meese 2009), fewer than half (46%) of colonies, comprising nearly 133,000 nesting birds (58% of the total number with known outcomes), were conserved, whereas nearly half (46%) of the colonies, representing 42% of the total population, were lost to harvest (Tables 1 and 2). In 2008, the statewide Tricolored Blackbird survey yielded a statewide population estimate of 395,000, so reproduction of roughly 22% of this population was eliminated. Assuming that each tricolor attempted breeding twice per year (Beedy et al. 2018) and

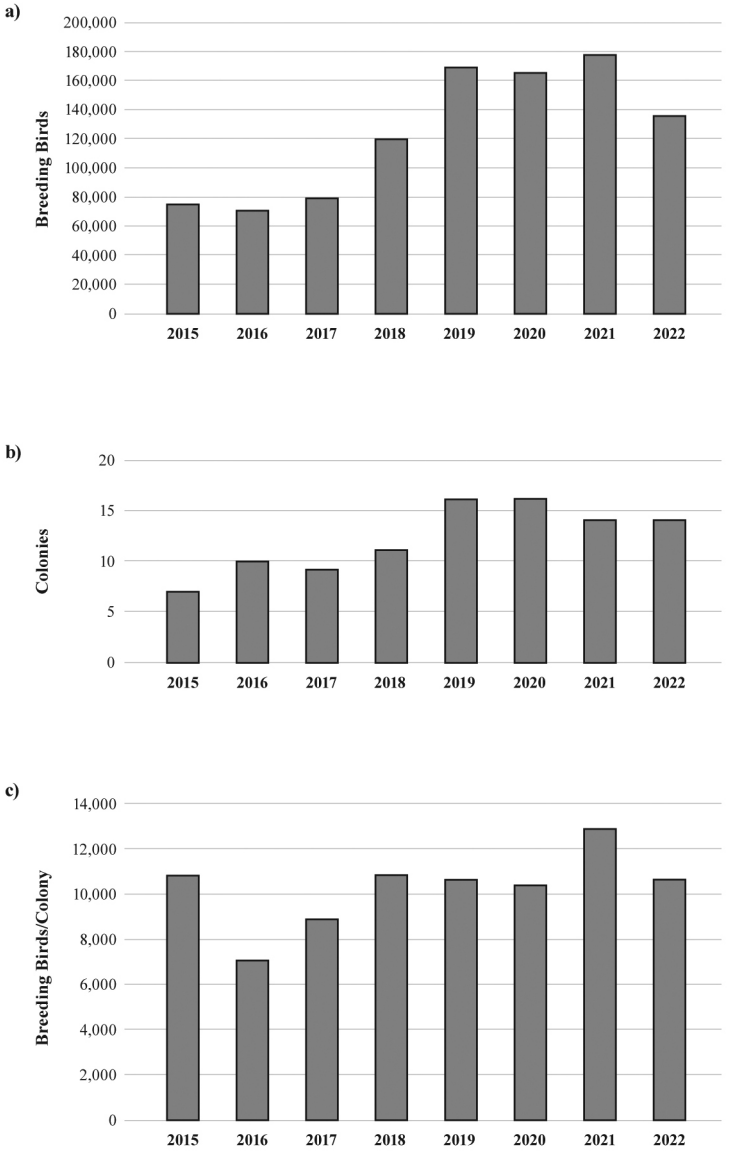

FIGURE 1. Numbers of (a) breeding birds, (b) colonies, and (c) average colony sizes of the Tricolored Blackbird in silage fields in the San Joaquin Valley, 2015–2022.

Table 2 Number of Colonies and Numbers of Tricolored Blackbirds Breeding in Dairy Silage Fields in the San Joaquin Valley During Two Periods of Comprehensive Monitoring Differing in Level of Conservation Effort

	Average annual numbers breeding		Average annual numbers conserved			Average annual numbers lost		
Period	No. colonies	No. breeding birds	No. colonies	No. breeding birds	% of total breeders	No. colonies	No. breeding birds	% of total breeders
2005–2009	7.4	228,410	3.4	132,860	60[a]	4	88,350	42[a]
2015–2022	12.1	124,262	11.4	119,500	96	0.6	5,443	4

[a]Percentages calculated for numbers of birds at colonies with known outcomes (see Table 1).

no adults were lost during harvest, roughly 11% of the species' productivity in California was lost during these five years.

2010–2014. Data on the tricolor's use of silage fields and on conservation and losses of colonies are incomplete for this interval (Table 1). The fragmentary information available indicates that 50,000–102,000 birds were protected in some years, but reproduction of at least 50,000 birds was lost in at least two years. The lack of information for this period suggests that monitoring and thus also likely conservation efforts were limited and that losses may have been greater than those reported.

2015–2022. For this period, the numbers of colonies and birds breeding, conserved, and lost are nearly complete (except the numbers lost at one colony in 2022). By all measures, conservation efforts were highly effective, with 91 (93%) of 97 colonies protected and an annual average of 119,500 breeding birds (96% of all breeders with known outcomes) protected. No losses occurred in half of the years (Tables 1 and 2). From 2017 to 2021 the number of colonies in silage increased by two-thirds, the number of breeding adults increased by 99,000 (127%), and average colony size more than doubled. (Figure 1, Table 1). The number of colonies remained at 14 in 2022, but the number of breeders with known outcomes declined by 23% to 137,500.

Conservation Costs

Over the three periods for which data are available, reimbursement costs per colony conserved increased gradually in response to increases in the

Table 3 Average Numbers of Breeding Tricolored Blackbirds Protected Annually and Average Costs of Payments to Landowners in the San Joaquin Valley over Three Periods

	Average no. protected per year		Average annual cost ($)	Average cost per colony ($)	Average cost per breeding bird ($)
Period	Colonies	Breeding birds			
2005–2009	3.4	132,860	63,400	18,647	0.48
2012–2014	4.7	81,125	125,100	21,617	1.75
2015–2021	11.0	118,643	277,100	25,200	2.34

crop's market value (Table 3). The cost of protection per breeding bird nearly quintupled from 2005–2009 to 2015–2021.

Creation of Alternative Habitat

Although information is incomplete, from 2014 to 2018 the NRCS supported summer flooding of wetlands at the U.S Bureau of Land Management's Atwell Island, Tulare County, which hosted 10,000–20,000 nesting Tricolored Blackbirds (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ca/newsroom/releases/?cid=NRCSEPRD1343418). From 2017 to 2021 the NRCS paid $557,000 for summer flooding at 10 sites representing 488 ha in Merced and Kern counties. Tricolors occupied at least one of these sites, which fledged young (T. Moore pers. comm.). During this period, CalDFW has also managed portions of several state wildlife areas to provide semi-permanent wetlands for tricolor nesting. The department's Private Lands Incentive Program also contracted with hundreds of landowners annually to create thousands of acres of semi-permanent wetlands in areas typically flooded only in winter for duck hunting. Monitoring these wetlands was challenging because of the wide application of the program. For the most part it was limited to verifying through field visits or by remote sensing that the wetlands were flooded in spring. Therefore, the program's effectiveness in supporting nesting tricolors is unclear. The increase in birds nesting in dairy silage fields from 2015 to 2021 (Figure 1), however, demonstrates that creation of new habitat elsewhere did not draw nesting tricolors away from these fields.

Potential Effects on the Statewide Population

The changes in the statewide estimates of the tricolor's population since 2014 show a parallel with the silage population, suggesting a connection between protection of colonies and the growth in both the silage-nesting and the statewide populations. Over the 15 years during which five statewide surveys followed a standardized method, two-thirds to three-fourths of the statewide population nested in silage fields until 2017, when this proportion dropped to less than half (Table 4). Harvest had been eliminating reproduction by a fourth to a third of the estimated statewide population until 2015,

Table 4 Estimates of the California Population of the Tricolored Blackbird from Four Years of the Statewide Survey, with the Percentages Nesting in Silage Fields and Conserved and Lost to Harvest

Year	Statewide population estimate[a]	Percent of statewide population		
		Nesting in silage fields	Conserved in silage fields	Lost to harvest in silage fields
2008	395,000	76%	41%	35%
2011	258,000	66%	43%	23%
2014	145,000	76%	41%	34%
2017	177,000	45%	36%	8%
2022	218,000	63%+	63%	unknown[b]

[a]Sources: Kelsey 2008, Kyle and Kelsey 2011, Meese 2014, 2017a.

[b]One colony was lost to harvest, but before any estimate was made of the number of breeders.

when losses declined substantially (Tables 2 and 4). As nearly full protection of colonies continued, the proportion of the statewide population using silage rebounded. Statewide survey totals paralleled this pattern, with declines from 2008 to 2014, a 22% increase in 2017 after two years when most colonies were conserved, and a further increase by 23% to 218,000 in 2022.

DISCUSSION

The Regional Conservation Partnership Program and related actions were highly successful in minimizing losses of tricolor colonies to silage harvest, with over 93% of colonies and 96% of birds breeding in triticale being left undisturbed. These percentages were substantially greater than from 2004 to 2009. The effects of the losses of a few colonies despite this effort probably varied with the timing of nesting and the harvest. In 2021, both colony sites were lost prior to egg-laying (Colibri 2021), so the birds may have had time sufficient for renesting elsewhere. The colony loss in 2022 also occurred early.

Whether near-complete protection of silage colonies during 2015 and 2016 (Table 1) contributed to the increase in the statewide population from 2014 to 2017 (Table 3) is unclear, as despite protection from 2015 to 2017, the size of the population nesting in silage fields did not increase substantially until 2018 (Figure 1, Table 1). Birds produced in silage fields may have shifted to breed in other regions as they do with changing weather and habitat conditions (Hamilton 1998, Airola et al. 2018a, Beedy et al. 2018, Robinson et al. 2018). Better survey coverage in Monterey and San Benito counties and other causes also may have contributed to the observed increase in the population during this period (Meese 2017a).

The decline in the proportion of the population using silage fields in 2017 (Table 4) could have resulted from multiple causes, including low recruitment in previous years and attraction to high-quality alternative nesting and foraging habitat conditions elsewhere after a winter of precipitation well above average followed five years of drought (CalDWR 2017). The substantial increase in the silage-nesting population after 2017 (Figure 1, Table 1) suggests that the conservation measures boosted local breeding recruitment.

The high counts of tricolors nesting in San Joaquin Valley silage fields in 2021 could include some birds that might have relocated to silage fields as the drought that year (CalDWR 2022) reduced the quality of habitat elsewhere (Colibri 2021). This hypothesis is supported by the low number of birds breeding in the foothills of the central Sierra Nevada in 2021, when the population of 36,300 breeders was >15,000 fewer than that area's average from 2014 to 2019 (Airola unpubl. data). The decrease in numbers in silage fields in 2022, when rainfall was higher, also coincided with a recovery of numbers breeding in the central Sierra foothills to the average, suggesting a shift in breeding locations. Thus recruitment from protected silage files may have contributed to the increase in the 2022 statewide population and may be offsetting losses elsewhere as habitat is converted to unsuitable crops and development.

The success in colony protection in San Joaquin Valley dairy silage fields from 2015 to 2022 is attributable to several key factors. The Regional Conservation Partnership Program provided secure, multi-year funding to support

partners in the comprehensive efforts at tricolor conservation. The historical and recent statewide survey data (Meese 2015a, 2017a) showed a clear and rapid population decline, which created urgency that led to the species' listing under the California Endangered Species Act. The listing increased attention and funding for conservation programs and added incentives for full participation by dairy producers. Establishment and maintenance of the Tricolored Blackbird Working Group facilitated information exchange and built trust among the dairy community, agencies, conservation groups, and other partners.

Development and application of clear protocols and roles for detecting and monitoring colonies (Meese 2011, Colibri 2021) and quickly reaching out to landowners through dairy associations (Audubon California 2020) were critical to success. Good communication strategies and networks among and within the producers, environmental nonprofits, and agencies (ibid.) improved the program's effectiveness and efficiencies. Adoption of an adaptive approach allowed adjustment of strategies and de-emphasis of program elements that were too complicated and ineffective, such as creation of "silage banks" to replace farmers' crop losses and special crop-insurance programs. These lessons should be useful to similar conservation efforts.

Despite the substantial gains in the number of tricolors nesting in silage, the goal for recovery of a population of 700,000 (TriBWG 2007, Meese et al. 2015, Beedy et al. 2018) is still far from met (Meese 2022). Persistent application of the measures we have described will be necessary to continue fostering recovery because creation of alternative habitat has not redirected a substantial proportion of tricolors nesting in silage and habitat elsewhere continues to decline (Beedy et al. 2018, Clipperton 2018). Recovery will require a continued private and public partnership to secure the funding and resources necessary to monitor and protect tricolor colonies, to provide fair compensation to maintain dairy producers' support, and to develop new means of reducing conflicts between the tricolor's nesting and agriculture. Continued attention to these and other all the factors threatening the Tricolored Blackbird is needed to secure its recovery.

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