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## LETTER

## Farmer Perceptions and Behaviors Related to Wildlife and On-Farm Conservation Actions

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### Keywords

Agri-environment; agriculture; bats; birds; gender; land management; organic; opinion; policy; raptor; survey.

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### Abstract

Policy makers are increasingly encouraging farmers to protect or enhance habitat on their farms for wildlife conservation. However, a lack of knowledge of farmers' opinions toward wildlife can lead to poor integration of conservation measures. We surveyed farmers to assess their perceptions of ecosystem services and disservices from perching birds, raptors, and bats—three taxa commonly targeted by conservation measures. The majority of farmers thought that perching birds and bats were beneficial for insect pest control and that raptors were beneficial for vertebrate pest control; however, fruit farmers viewed perching birds more negatively than did farmers growing other crops. Farmers using organic methods viewed all three wildlife groups more positively than conventional farmers. Farmer perception toward each wildlife group predicted their action to either attract or deter those taxa, suggesting the need to focus research and outreach on the effects of wildlife on farms for conservation programs to positively influence farmer perceptions.

## Introduction

Global biodiversity loss in agricultural landscapes jeopardizes the persistence of many threatened species, and is linked with the loss of ecosystem services (Perrings *et al.* 2006, Morandin *et al.* 2016). In the United States, crops are grown on over 13.2 million hectares of private land (326 million acres; USDA 2015), covering roughly 14% of the country. Agricultural lands therefore provide a crucial, but often overlooked, opportunity for wildlife conservation efforts, and farmers and ranchers are a vital group to help foster this potential (Perrings *et al.* 2006).

Conservation practices can increase local biodiversity (e.g., Fahrig *et al.* 2011; DiGaudio *et al.* 2015; Heath *et al.* in review), and provision farmers with biodiversity-mediated services including pest control (e.g. Morandin *et al.* 2014; Maine and Boyles 2015; Kross *et al.* 2016), and pollination (e.g., Morandin *et al.* 2016). To encourage

these practices, local and government support for farmers to foster wildlife habitat on farms has become more prevalent. For example, in the European Union, over €20 billion was spent on agri-environmental schemes as part of the Common Agriculture Policy between 2007 and 2013 (European Commission 2016). In the United States, programs such as the United States Department of Agriculture's (USDA) Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP), provide financial support through the Agricultural Act of 2014 (commonly known as the Farm Bill) to producers to implement conservation practices on working landscapes and to groups such as the USDA's Natural Resources Conservation Service (NRCS) to educate farmers about the benefits of these practices. For these practices to successfully facilitate ecosystem service provisioning and biodiversity conservation they need to be implemented over large spatial and temporal

scales (Batáry *et al.* 2011), all of which necessitates farmer support (Lovell & Sullivan 2006; Brodt *et al.* 2009; McCracken *et al.* 2015). Furthermore, social and environmental theory suggest that for such schemes to have longevity they must understand and influence both the societal moral of farming communities and the personal norms of individual farmers (de Snoo *et al.* 2013).

Bats, perching birds (hereafter: birds), and raptors are the focus of numerous conservation efforts (e.g., hedgerows, bat boxes, nest boxes, raptor perches). All three wildlife groups are common and can provide valuable ecosystem services for farmers (e.g., Boyles *et al.* 2011; Kunz *et al.* 2011; Kross *et al.* 2012, 2016). However, they have also been associated with negative impacts for farmers (Thirgood & Redpath 2008; Hassan *et al.* 2011; Gebhardt *et al.* 2011; Kross *et al.* 2012). Furthermore, many species of bats, raptors, and birds are negatively affected by agriculture worldwide thus, effective conservation of these and other wildlife species will rely on farmer participation in conservation efforts. Perceptions of environmental issues are known to be a significant driver in farmer beliefs and attitudes, and ultimately, can influence the adoption of environmentally-friendly behaviors (Haden *et al.* 2012; Niles *et al.* 2015) and interest in participating in government programs (Niles *et al.* 2013). Understanding these perceptions is therefore critically important for developing targeted outreach programs, guiding technical research, and informing agri-environmental policy.

California's Central Valley is critically significant to agricultural production in the United States (USDA 2015) and serves as a model system for our study. This system is the focus of ongoing conservation efforts including flooding fields for waterfowl and wading birds (e.g., Elphick 2004), installing owl and bat boxes on farms (Long *et al.* 2006), and planting hedgerows for wildlife (e.g., Heath *et al.* in review). Although many private, state, and federal organizations provide technical and financial support for conservation strategies within the Central Valley, farmer participation and interest in these programs remains modest (Lovell & Sullivan 2006; Garbach & Long 2017).

We investigated farmer participation in conservation efforts by directly assessing farmer opinions about wildlife on crop lands based on four main hypotheses. First, we hypothesized that, compared to conventional farmers, organic farmers would view birds and bats as more beneficial given limited alternative pest control methods (H1). Second, because women are more likely than men to express an interest in learning about and interacting with wildlife (Miller and McGee 2000), we hypothesized that female farmers would view all wildlife as more beneficial to crops and livestock than do male farmers (H2). Third, we hypothesized that compared to

other farmers, fruit or seed crop farmers would perceive birds as more harmful because they can damage crops (Gebhardt *et al.* 2011), (H3). Finally, we hypothesized that perceptions of wildlife would be associated with behaviors intended to attract or deter wildlife (H4).

## Methods

We developed a survey to assess the opinions of farmers concerning wildlife on their managed lands (full survey: Appendix 1). The survey was mailed to 500 randomly selected farmers from a list of 2,952 farmers across a five county area in California's Central Valley and employed a modified Dillman method with one reminder postcard to encourage the highest level of participation by respondents (Dillman 2007). An identical survey was also available online and was open to any California farmers. T-tests to compare the responses of mail and online surveys revealed only minor differences (see Appendix 2), so we grouped all data for our formal analyses. We received 75 returned surveys through the mail and 47 responses to the online survey. Our total response was therefore 122, giving us a response rate of 22.3% (AAPOR 2010, version 3.1 2010). A demographic breakdown of survey respondents is given in Table 1. All data was analyzed in Stata 13.0 (StataCorp 2013)

We ran a principle factor analysis to assess whether perceptions of bats, birds, and raptors across many questions were similar and could be used to create a scale variable, which averages responses over questions with multiple similar answers. Overall we found that all variables loaded acceptably ( $<0.40$ ; Costello and Osborne 2005) or close to acceptable ( $<0.35$ ) into one factor with the exception of insect control by bats and raptors. However, we created a single scale variable out of all of the factors because the Cronbach alpha score for internal validity was near or above 0.70 for all scales, a good level of fit (Nunnally 1978; Bat Perception Scale alpha = 0.77; Bird Perception Scale alpha = 0.82; Raptor Perception Scale alpha = 0.68; Appendix 3). Scale variables represent the overall perception held by individuals on bats, birds, and raptors, and given the high level of internal consistency, suggest that individuals generally had a similar response to all of the questions about one type of animal. We used an ANOVA with Scheffé's multiple comparison tests to determine the between-group variances and significance for bat, bird, and raptor scale perceptions as well as all individual variable perceptions. Scheffé tests not only allow for comparison across groups with multiple categories but are also conservative since they reduce the likelihood of a Type I error. Results are presented with mean values ( $\pm 1$  standard error) for responses based on a Likert scale

**Table 1** Demographic breakdown of survey respondents and number of respondents reporting that they grow each category of crop. Note that many individuals grow more than one crop

Question	Responses (number of respondents)
Farmer gender	Female (30), Male (87), No response (5)
Farmer age	Over 60 (62), 50–59 (26), 40–49 (17), 30–39 (13), 20–29 (3)
Farmer education level	High school (11), College (81), Graduate school (28), No response (2)
Mean farm size $\pm$ 1 standard error	446 $\pm$ 149 ha; range 0.41 ha – 8094 ha
Farming methods	Organic/ Transition to Organic (20), Conventional (68), Dual-approach (33)
Grows forage crops (alfalfa, wheat, corn, oats)	Yes (32), No (83), No response (7)
Grows vegetable crops (tomatoes, peppers, beans)	Yes (27), No (88), No response (7)
Grows nut crops (almonds, walnuts, pistachios, pecans)	Yes (48), No (67), No response (7)
Grows fruit crops (berries, stonefruit, grapes, melons)	Yes (32), No (83), No response (7)
Grows seed crops (sunflower, safflower, vegetable seed)	Yes (12), No (103), No response (7)
Grows rice	Yes (23), No (92), No response (7)
Raises livestock (cattle, pigs, sheep, goats, poultry)	Yes (35), No (87), No response (7)

representing response options as follows: (1) very harmful, (2) somewhat harmful, (3) neutral, (4) somewhat beneficial, and (5) very beneficial. Finally, we developed five separate multinomial logistic regression models to determine factors that influenced multiple farmer behaviors related to wildlife. Specifically, we tested for a relationship between farmer behavior (attracting bats, birds, or raptors, and deterring birds) and the farmer's positive or negative opinions of wildlife, as well as demographic controls including farmer age, education, sex, farm size, and farm type (Table 1). The small number of farmers who wanted to deter bats ( $n = 11$ ) and raptors ( $n = 1$ ) prevented us from running these models for predicting farmer use of bat or raptor deterrents.

## Results

### Bats

Overall, survey respondents viewed bats as being very beneficial for insect pest control, and somewhat beneficial for crop yields (Figure 1). Respondents were neutral on the effects of bats on food safety, and thought bats

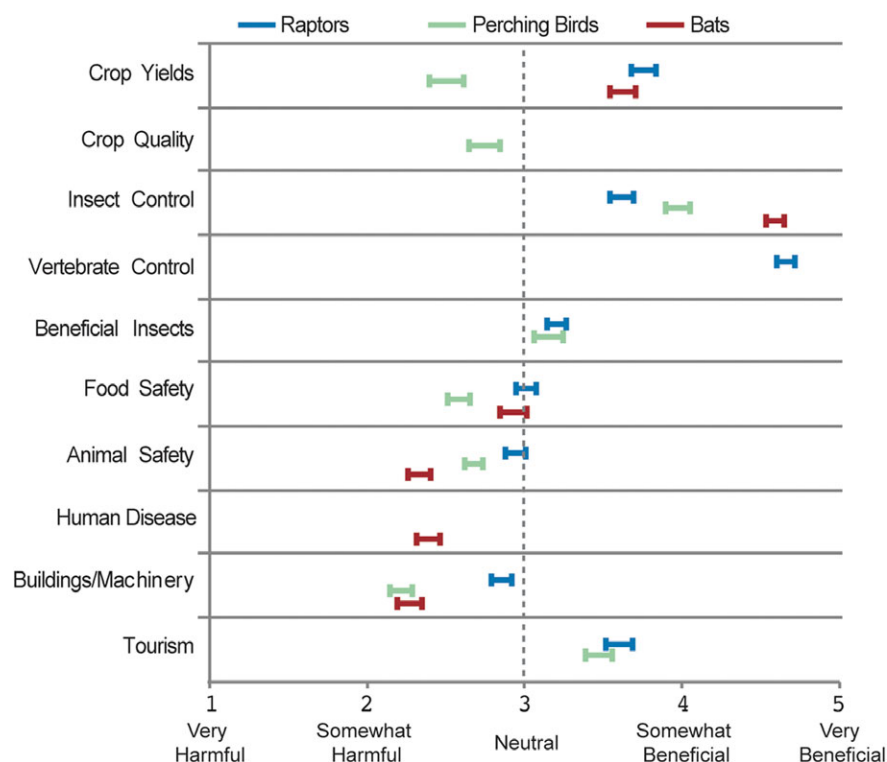
were somewhat harmful for human disease, animal disease, and machinery/buildings (Figure 1). Organic farmers viewed bats as more beneficial than did conventional farmers for crop yields (H1; organic =  $3.95 \pm 0.15$ , conventional =  $3.46 \pm 0.09$ ,  $P < 0.05$ ), and less harmful for machinery (organic =  $2.95 \pm 0.17$ , conventional =  $2.19 \pm 0.10$ ,  $P < 0.01$ ; Appendix 4). Female farmers viewed bats as more beneficial than did male farmers overall, on insect pest control, crop yields, and machinery/buildings (H2; Table 2). Similarly, farmers of different crop types did not differ in opinions toward bats except that nonfruit farmers viewed bats as more beneficial for crop yields than did fruit farmers ( $3.78 \pm 0.09$ ,  $P < 0.01$ ), rice farmers believed that bats were less harmful ( $2.0 \pm 0.19$ ) for buildings/machinery than nonrice farmers ( $2.42 \pm 0.08$ ,  $P < 0.05$ ), and farmers raising livestock thought bats were more beneficial ( $4.81 \pm 0.07$ ) for insect pest control and less harmful for crop yields ( $3.96 \pm 0.14$ ) than farmers not raising livestock ( $4.52 \pm 0.07$  and  $3.55 \pm 0.08$ , respectively; both  $P < 0.01$ , Appendix 4). The multinomial logit model revealed that farmers with positive bat opinions were significantly more likely to invest in attracting bats to their farms (H4;  $P < 0.05$ ) conventional farmers were less likely to invest in bats compared to organic growers ( $P < 0.05$ , Table 3).

### Perching birds

Overall, farmers viewed perching birds as beneficial for insect pest control, beneficial insects, and tourism but harmful for crop yields, crop quality, food safety, machinery/buildings and animal safety (Figure 1). Farmers using organic methods had more positive opinions of birds, while farmers using conventional or dual methods had more negative opinions of birds (H1; Figure 2). Female farmers viewed birds as beneficial, whereas male farmers viewed birds as slightly harmful overall, and for crop yields, crop quality, and tourism (H2; Table 2). Both women and men viewed birds as beneficial for insect pest control (H2; Table 2). Fruit farmers differed significantly from nonfruit farmers in their opinions of birds (H3; Figure 2). Farmers with positive opinions toward birds were significantly more likely to invest in attracting birds, and significantly less likely to invest in bird deterrents, while fruit farmers were significantly less likely to invest in attracting birds (H4; Table 3).

### Raptors

Farmers were overwhelmingly positive about the beneficial role of raptors for vertebrate pest control, and thought that raptors were also beneficial for insect pest control and for crop yields (Figure 1). Farmers using



**Figure 1** Overall opinions of all survey participants toward the effects of perching birds, bats, and raptors on farm operations. Lines show  $\pm 1$  standard error of the mean.

dual methods thought raptors had a slightly harmful effect on food safety ( $2.87 \pm 0.08$ ), conventional farmers thought raptors were neutral ( $3.04 \pm 0.08$ ), and organic farmers thought raptors had a beneficial effect on food safety (H1;  $3.40 \pm 0.17$ ,  $P < 0.05$ ). There were no significant differences between female and male farmers' opinions toward raptors (H2; Table 2). The only significant differences amongst farmers of different crops was that rice farmers thought raptors were slightly more harmful to buildings/machinery ( $2.62 \pm 0.23$ ) and less beneficial to crop yields compared to farmers who did not farm rice (buildings/machinery:  $2.95 \pm 0.06$ ,  $P < 0.05$ ; crop yields:  $3.92 \pm 0.08$ ,  $P < 0.01$ ). All other crop-based differences in opinion toward raptors were nonsignificant (Appendix 4). Farmers with positive opinions about raptors were significantly more likely to invest in attracting raptors to farms (H4;  $P < 0.05$ , Table 3).

## Discussion

Farmer opinion toward wildlife targeted by on-farm conservation programs will influence participation in such programs (Lovell & Sullivan 2006; McCracken *et al.* 2015), especially if the target species are per-

ceived as either beneficial or detrimental (Conover 1998; Brodt *et al.* 2009). Although nearly \$6 billion (USD) was spent on agricultural conservation measures in the United States in 2010 (Reimer 2013), to our knowledge, our study is the first to investigate farmer perceptions of both ecosystem services and disservices from three wildlife groups, which are also the focus of many on-farm conservation measures. Our study shows that perceived benefits or costs from wildlife are the strongest driver of practice adoption, regardless of farmer demographics and farm type. This finding is significant in that it suggests that if farmer opinions about wildlife can be influenced by outreach and education, these perceptions can readily translate into land management decisions by all types of farmers.

We found crucial differences between organic and conventional farming practices in farmer opinions toward both birds and bats (H1). This differs from a previous study in Florida where conventional and organic farmers did not differ in their perceptions of birds (Jacobson *et al.* 2003). It is possible that while all farmers recognize that birds and bats consume pest insects, organic farmers have few alternative pest control methods and therefore rely more on natural enemies. For example, bat activity

**Table 2** Opinions of female and male farmers toward the effects of bats, perching birds, and raptors on various aspects of farming. Significance of results from an ANOVA with Scheffé multiple comparison tests are shown next to each category name. Mean values (shown  $\pm$  1 standard error) based on a Likert scale are shown representing response options as follows: (1) very harmful, (2) somewhat harmful, (3) neutral, (4) somewhat beneficial, and (5) very beneficial

Animal group	Animal effect on	Women	Men	F-Statistic	P
Bats	Overall	3.32 (0.12)	3.04 (0.06)	4.60	0.03
	Crop Yields	4.09 (0.15)	3.54 (0.08)	8.19	0.01
	Insect Pest Control	4.83 (0.07)	4.53 (0.07)	5.68	0.02
	Food Safety	3.23 (0.15)	2.95 (0.09)	1.91	0.17
	Animal Safety	2.37 (0.13)	2.38 (0.09)	0.39	0.53
	Human Disease	2.35 (0.13)	2.45 (0.08)	0.01	0.93
	Buildings/Machinery	2.64 (0.14)	2.25 (0.09)	4.75	0.03
Perching Birds	Overall	3.28 (0.11)	2.84 (0.07)	9.73	<0.01
	Crop Yields	3.12 (0.22)	2.38 (0.11)	8.89	<0.01
	Crop Quality	3.38 (0.17)	2.6 (0.11)	11.83	<0.01
	Insect Pest Control	4.29 (0.17)	3.9 (0.08)	4.67	0.03
	Beneficial Insects	3.32 (0.19)	3.18 (0.10)	0.40	0.53
	Food Safety	2.88 (0.11)	2.56 (0.08)	3.58	0.06
	Animal Safety	2.88 (0.08)	2.68 (0.07)	2.04	0.16
	Buildings/Machinery	2.43 (0.13)	2.22 (0.09)	1.32	0.25
	Tourism	3.8 (0.16)	3.45 (0.09)	3.04	0.08
Raptors	Overall	3.59 (0.09)	3.54 (0.05)	0.29	0.59
	Crop Yields	3.59 (0.15)	3.84 (0.09)	1.79	0.18
	Insect Pest Control	3.79 (0.17)	3.57 (0.08)	1.58	0.21
	Vertebrate Pest Control	4.72 (0.12)	4.66 (0.07)	0.25	0.62
	Beneficial Insects	3.28 (0.11)	3.22 (0.06)	0.22	0.64
	Food Safety	3.04 (0.04)	3.09 (0.08)	0.12	0.73
	Animal Safety	2.85 (0.11)	3.08 (0.07)	2.45	0.12
	Buildings/Machinery	2.96 (0.11)	2.89 (0.08)	0.35	0.55
	Tourism	3.73 (0.15)	3.63 (0.09)	0.26	0.61

**Table 3** Multinomial logistic regression results for models testing the correlations between farmer behavior to deter or attract wildlife from their farms as correlated to the farmer opinion toward wildlife

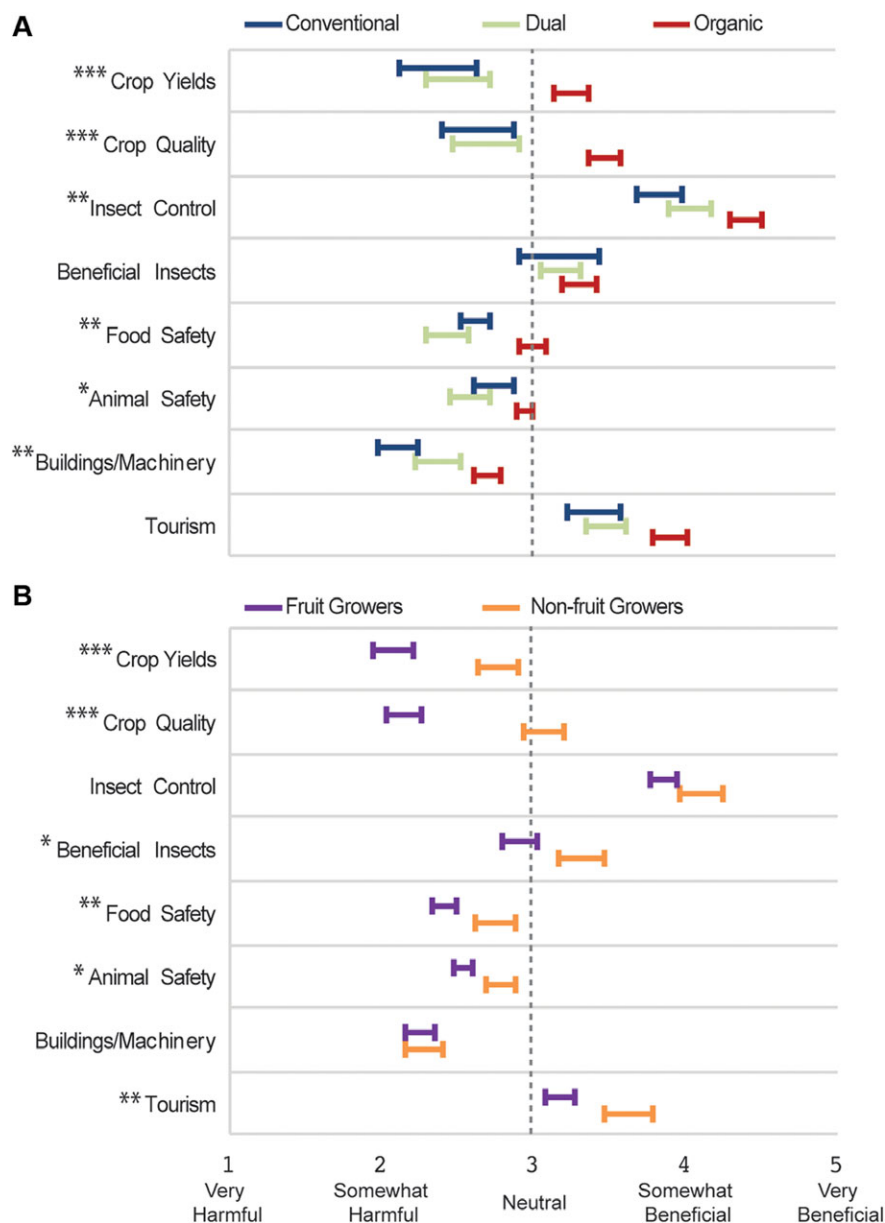
	Invest to attract bats	Attract songbirds	Deter songbirds	Attract raptors
Perception scale	1.05**	0.97**	-1.35***	0.95**
Farming methods- conventional	-1.21**	-0.67	0.11	-0.75*
Farmer gender	-0.07	-0.42	-1.08	0.27
Farmer Education level	0.70	0.35	0.72	-0.09
Farm Size	-0.0001	-0.001	<0.001	<0.001
Farmer Age	0.11	0.09	-0.03	-0.15
Grow fruit <sup>a</sup>		-1.42**	-0.32	
Pseudo-R <sup>2</sup>	0.16	0.12	0.17	0.07

<sup>a</sup>A crop-specific variable for fruit farmers was only included for the models for songbirds. Statistical significance is denoted using. \*For  $P < 0.1$ , and \*\*for  $P < 0.05$ . \*\*\*for  $P < 0.01$ .

may be up to 60% greater on organic versus conventional farms (Wickramasinghe *et al.* 2003). However, few studies have quantified the ecosystem services provided by wildlife to conventional farmers (but see Kunz *et al.* 2011; Kross *et al.* 2016). Because conventional farming is far more common than organic farming in many developed regions, further research to understand the role of birds and bats for controlling insect pests in conventional

crops is critical to informing conventional farmers about the benefits of enhancing wildlife habitat on their farms, and our results suggest that this will in turn have positive effects on farmer implementation of conservation-oriented practices.

Our results show that female farmers have more positive opinions than men concerning bats and birds (H2), but not raptors though both groups had very



**Figure 2** Opinions toward perching birds of (a) farmers utilizing organic, conventional or dual methods; and of (b) farmers who grow fruit crops and who do not grow fruit crops. Lines show  $\pm 1$  standard error of the mean, significance of results from an ANOVA with Scheffé multiple comparison tests are shown next to each category name, with \*denoting  $P < 0.1$ , \*\*denoting  $P < 0.05$ , and \*\*\*denoting  $P < 0.01$ .

high opinions of raptors. This finding is consistent with existing literature demonstrating that women are more likely than men to express an interest in learning about and interacting with wildlife (e.g., Miller and McGee 2000). Because the majority (86%) of farmers in the United States are men (USDA 2014), we recommend that ongoing outreach efforts for all farmers focus on highlighting the benefits of birds and bats where those benefits have been quantified.

We found surprisingly few differences between farmers growing different crop types, aside from our hypothesized difference in fruit farmers’ opinions toward birds (H3). It is not surprising that fruit farmers perceive birds as harmful to crop yields and crop quality, since birds are a key pest of fruit crops globally (Gebhardt *et al.* 2011; Kross *et al.* 2012). However, fruit farmers also viewed birds more negatively than nonfruit farmers in all other categories in our survey, aside from their effects on

buildings/machinery. These opinions were also reflected in farmer behavior: fruit farmers were far less likely to invest in bird attraction and, in general, farmers with negative opinions of birds invested in more bird deterrents. Thus, negative interactions with birds (consumption or damage to crops) are likely influencing farmer perceptions of potential beneficial services provided. Bird damage to crops causes significant yield losses worldwide (De Grazio 1978), but relatively few field studies have quantified patterns of bird damage to fruit crops (but see Kross *et al.* 2012; Somers & Morris 2002). Intriguingly, flocking birds cause the bulk of damage to fruit crops and prefer to forage in areas further from trees (e.g., Kross *et al.* 2012), suggesting that planting or protecting habitat to attract birds may not equate to more damage for fruit farmers.

Farmers perceived bats as having harmful effects on human disease and animal safety/disease, even though bat-borne diseases such as rabies are preventable through prevaccination and avoiding handling of bats (Manning *et al.* 2008). Guano and urine from bats can corrode machinery and buildings, but such potential damage can be avoided through careful instruction and outreach concerning practices such as bat box installation. It is interesting that farmers who did and did not raise livestock expressed similar (negative) opinions about bats and animal safety, perhaps suggesting that the general and negative association between bats and disease risk is driven largely by popular notions or social norms, rather than actual experience or factual information. Such trends in farmer opinions may underlie hesitancy to adopt wildlife conservation efforts aimed at bats.

Effective conservation on farmland depends not just on economic incentives for farmers, but also on understanding the underlying psychology of farmer behavior with respect to conservation concerns (de Snoo *et al.* 2013). We did not explicitly quantify farmers' cultural perceptions of bats, birds and raptors, which could influence their opinions of wildlife (Chan *et al.* 2012), and disentangling the interactions between the cultural values and economic values placed on wildlife by farmers may be difficult. For example, one farmer's response to an open-ended question on their opinion of birds stated: *"I think birds are great and love to hear them in the orchard. We have some birds that cause fruit damage but not too much. We really want more owls/prey birds to control rodents."* Understanding the importance of both cultural and economic values may be an important consideration for outreach efforts targeted at increasing farmer participation in conservation programs. In addition, while we believe that these results are applicable to farmers in all regions, our study area is in a Mediterranean climate and growers in other regions may encounter different insect pests and different

populations of vertebrate insect predators, which could change farmer opinions of these groups. Future studies might attempt to quantify the impact of seasonality on farmer perceptions of wildlife.

Land management decisions made by farmers can affect biological and physical systems. Thus, the positive and negative opinions that farmers have of bats, birds, and raptors may have wide-ranging implications for the adoption of practices that benefit wildlife without impacting food production. To date, surveys of farmers have mainly concentrated on negative perceptions of wildlife on farms, specifically on identifying key detrimental vertebrate pests, and quantifying the amount of money spent on deterring or destroying these pests (i.e., Conover 1998; Gebhardt *et al.* 2011). Our results suggest that further research and outreach targeting better understanding of the costs and benefits of bats, birds, and raptors on conventional farms will be critical to enhancing uptake and longevity of wildlife conservation practices. Our results linking farmer perceptions of wildlife to their participation in conservation actions highlights the need for ongoing research, targeted outreach, and policy tools that empower farmers to make informed decisions about agri-conservation practices that benefit wildlife.

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## Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

**Appendix S1.** Copy of full survey and cover letter

**Appendix S2.** Survey methods and responses received from mail and online respondents, including Table S1, Demographics of online vs. mailed surveys showing the percentage of respondents within each category; and Table S2, General opinions of farmers responding to survey by mail (random sample from 5 counties) or online (voluntary responses open to all regions of California).

**Appendix S3.** Factor loadings, eigenvalues, and Cronbach alpha for the three scales created for bat, bird, and raptor perceptions.



**Appendix S4.** Full summary data on differences between farmer opinions based on gender, growing methods, and crops grown.

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