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Finding solutions for bird restoration and livestock management: comparing grazing exclusion levels

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Abstract. Riparian habitats in the western United States support high avian abundance and diversity and are important areas for livestock grazing, although grazing contributes to the degradation of riparian vegetation. Complete removal of livestock is generally the most beneficial for bird communities, but alternative management approaches allowing for seasonal livestock grazing may also increase avian habitat quality. Determining management approaches that integrate conservation priorities and human use has the potential to improve conditions for birds across many grazed landscapes. We anticipated that both the full and seasonal exclusion of cattle from riparian areas would result in the recovery of avian populations. To test this, we experimentally compared the effects of total cattle exclusion vs. seasonal usage on bird populations in the riparian areas of two creeks in the San Joaquin Valley, California, USA. Avian species richness and average abundance were measured over six years, from 2001 to 2006. In general, native avian abundance and richness increased in both full- and seasonal-exclosure areas, with increases compared to the pretreatment year for all years except 2005. Habitats that had complete cattle exclusion recovered more significantly, with 29% lower avian abundance in seasonally grazed habitats. There was no significant difference in avian richness between the two grazing treatments, although richness did increase over time. In addition to increases in native species, abundance of nonnative birds and brood parasites also increased significantly, with a greater avian abundance in the full-exclusion areas. A direct comparison with the Breeding Bird Survey (BBS), to further investigate annual avian population trends, explained the native species decline in 2005. This comparison revealed that observed trends were the effect of experimental treatment rather than a reflection of regional trends. Although the overall trends indicate that the full exclusion of livestock from riparian areas results in more abundant bird populations, seasonal exclusion is also a successful method for avian recovery. Land managers should consider both options in riparian areas, selecting full cattle removal for avian management only and seasonal cattle removal for situations where incorporating conservation and land use practices is advantageous.

Key words: avian conservation; Breeding Bird Survey (BBS); cattle exclosures; livestock grazing; rangeland management; riparian habitats; San Joaquin Valley, California, USA; seasonal exclusion; species restoration.

Introduction

Birds are significantly declining globally, due to habitat loss and other anthropogenic factors. Successful conservation therefore requires habitat restoration and removal of other factors contributing to the decline. Yet this approach often conflicts with other interests, including human use of the landscape. Therefore it is critical to find viable outcomes for bird populations, their habitat, and human populations. This study investigates a livestock management option that allows for both bird restoration and cattle grazing and details the resulting increases in avian abundance and diversity. Although the results are for riparian systems, similar approaches may be applicable to other important bird habitats.

Western riparian areas are highly productive habitats, with diverse vegetation and associated animal communities. Riparian habitats support more breeding birds than any other habitat type in the western United States, even though they only make up ~1% of the total land area (Saab and Groves 1992, Knopf and Samson 1994). This is particularly true for California, where riparian areas are the most important habitat type for avian communities (Gaines 1977). Riparian habitats are crucial for birds because they provide abundant water and vegetation resources; avian abundance and diversity increase with higher structural complexity of vegetation, because birds depend on riparian vegetation for foraging, nesting, and shelter (Hurst et al. 1980, Scott et al. 2003).

Although western riparian habitats are very productive and diverse, an estimated 89–95% of riparian land in the west has been lost or degraded, making it the most altered habitat type in the region (Jehl and Johnson

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1994, Saab et al. 1995, Larison et al. 2001). There are many sources of this damage, including development, water flow modification, and agriculture (Gaines 1974, Hurst et al. 1980, Rich 2002). The greatest threats to riparian biodiversity are land conversion and livestock grazing (Tewksbury et al. 2002). Over 150 years of livestock grazing has significantly affected western riparian areas, changing riparian community composition and ecosystem structure and negatively affecting the functionality of the ecosystem overall (Mosconi and Hutto 1982, Ohmart 1996, Dobkin et al. 1998, Scott et al. 2003). Specifically, cattle grazing changes plant species composition and abundance by trampling and browsing, alters nutrient cycling through hoof compaction of soil, and reduces plant recruitment (Schulz and Leininger 1991, Saab et al. 1995, McIntyre et al. 2003).

Bird populations generally have a lower abundance and diversity related to the reduced vegetation structural complexity from long-term cattle grazing (Saab et al. 1995, Scott et al. 2003). Factors such as the magnitude and timing of grazing determine the types of effects on birds and their habitat, ranging from foraging to reproductive impacts (Sedgwick and Knopf 1987, Knopf et al. 1988, Tewksbury et al. 2002). Livestock affect birds directly by reducing food resources and decreasing reproductive success from trampling and grazing, which damages vegetation structure and recruitment and changes plant species composition (Schulz and Leininger 1991, Saab et al. 1995, Martin and Possingham 2005). Potential indirect effects of livestock grazing on birds include the expansion of invasive species, along with increased brood parasitism, nest predation, and competition for food and nesting resources (Robinson et al. 1995, Ammon and Stacey 1997, Tewksbury et al. 2002, Bengsen and Pearson 2006).

In general, studies comparing avian communities in grazed and non-grazed sites demonstrate a significantly higher avian abundance and species diversity in the absence of livestock grazing (Dobkin et al. 1998, Popotnik and Giuliano 2000, Tewksbury et al. 2002). Because these studies show that riparian areas can recover quickly following cattle removal (Schulz and Leininger 1990, Krueper et al. 2003), they often are used to support management recommendations for complete cattle exclusion to restore this habitat type and its associated avian communities. What these management recommendations do not address, however, is the potential negative effects of complete cattle removal (such as the rapid invasion of weedy plant species), or the needs of ranchers. For example, weedy plant invasive species are often better adapted to recover from grazing, which can reduce native plant diversity (Kimball and Schiffman 2003).

Conversely, some studies have shown increases of certain riparian bird species in response to the presence of cattle grazing (Saab et al. 1995). There are also mixed views on other management approaches such as seasonal livestock grazing. Alternative management techniques can be effective in some cases, where moderate or late-season grazing is maintained in riparian areas (Saab et al. 1995, Stanley and Knopf 2002, Martin and McIntyre 2007). Late-season grazing minimizes the effects of cattle grazing and trampling on riparian plant growth and soil erosion, allowing for improved recovery of birds, although this recovery period is typically longer than that for full cattle removal (Saab et al. 1995, Stanley and Knopf 2002). However, other studies indicate that complete cattle exclusion is required for riparian restoration or that there is no difference in avian abundance and richness between ungrazed and seasonally grazed sites (Stanley and Knopf 2002, Tewksbury et al. 2002). Ultimately, wildlife and vegetation responses to the presence or removal of livestock grazing are complex, with potential positive and negative outcomes to both scenarios.

There is a lack of information, in general, on the long-term recovery of avian communities under different management scenarios. Many questions remain on how to effectively restore riparian habitat for a particular bird species or for avian biodiversity overall, while allowing for limited livestock grazing. Currently, no consensus exists as to whether cattle must be removed from riparian areas year-round, or whether seasonal removal is equally as effective at improving avian habitat. To address this, we compared the avian response to both the full exclusion and seasonal exclusion of cattle to (1) investigate differences in the long-term response of avian communities to both treatments in riparian areas; and (2) determine the benefits and risks of full vs. seasonal cattle exclusion for the recovery of bird populations. A direct comparison of these two treatment options will enable land managers to make better informed decisions regarding how best to restore riparian areas for avian communities while addressing ranching needs for human communities.

Methods

Study area

This study was conducted in the riparian areas of Orestimba Creek and Garzas Creek on the 32 986-acre (13 349-ha) Simon Newman Ranch. The study area is located in the foothills of the San Joaquin Valley in Stanislaus County, California, USA (Fig. 1). Grazing has been the primary land use of the Simon Newman Ranch since 1850 or earlier. When the ranch was purchased for conservation purposes in 1998, both creeks had evidence of many years of intensive grazing, including the loss of riparian vegetation, severely reduced recruitment and hedging of riparian trees and shrubs, insufficient stream shading, excessive erosion and siltation, and excessive nutrient loading in streams (The Nature Conservancy, *unpublished data* 1998).

Riparian vegetation along creeks in this region provides important habitat for avian populations, particularly given the surrounding arid environment.

Climate in the area is mediterranean, characterized by hot, dry summers, and warm, relatively moist winters. With average annual precipitation <220 mm, most of the precipitation occurs from October through May (NWS 2005). Creek beds are typically dry from June through mid-November, although residual pools persist through the dry season. Several riparian vegetation community types are located along Orestimba and Grazas Creeks. These include mixed riparian woodlands dominated by willows (*Salix* spp.) and Fremont cottonwood (*Populus fremontii*); sycamore alluvial willows characterized by California sycamore (*Plantanus racemosa*); and riparian scrub and herbaceous vegetation. The vegetation of the surrounding uplands, as well as much of the open riparian understory, is primarily a nonnative annual grassland.

Avian community sampling

We initiated this study in 2001 following the installation of full livestock fence exclosures in the lower reaches of Orestimba and Garzas Creeks in summer 2000, and seasonal livestock exclosures in the upper reaches of the same two creeks in spring 2001. The cattle exclosures completely eliminated grazing from the lower reaches, while grazing was permitted seasonally in the upper creek reaches, from 1 December to 15 April, before riparian seedlings began to leaf out. We controlled grazing impacts in the seasonally grazed exclosures by annually monitoring residual herbaceous dry matter (RDM) and requiring that stocking rates be adjusted to leave more than the average pounds per acre of RDM based on pasture slope as follows: 0–10 degrees slope, 700 pounds per acre (787.5 kg/ha); 11–20 degrees slope, 1000 pounds per acre (1125 kg/ha); and 20+ degrees slope, 1200 pounds per acre (1350 kg/ha). We consider data collected from spring 2001, recorded immediately after the exclosures took effect, to be the baseline or pretreatment data.

We collected avian data during the breeding season (April to June) from 2001 to 2006 using the variable circular plot method (VCP; Reynolds et al. 1980). Single transects with multiple point count stations were located within the riparian corridors of both the full- and seasonal-exclosure reaches of the two creeks. After designating a random starting point, each station was permanently marked and positioned 250 m apart along a single transect. The full-exclosure section of Garzas Creek had 22 point count stations and the seasonal-exclosure section had 16 point count stations. The full-exclosure and seasonal-exclosure sections of Orestimba Creek had 23 and 17 point count stations, respectively. A single observer was trained for each field season to identify birds by both sight and vocalization. During each survey, the observer identified individuals by species and the distance to each individual over a five-minute period at each station. We conducted surveys from 05:00 to 11:00 hours, suspending data collection only during rare periods of heavy rain or winds exceeding 30 km/h. Species names are from the American Ornithologists' Union (1998) checklist.

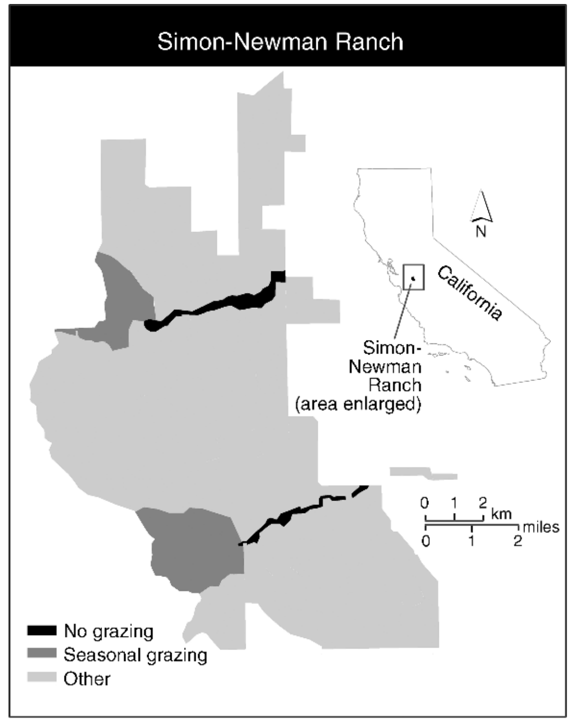

FIG. 1. Location of the study sites along Orestimba Creek and Garzas Creek in the Simon-Newman Ranch, California, USA. Each creek has two exclusion areas: full livestock exclusion (no grazing) and seasonal livestock exclusion (seasonal grazing). E. Simek of The Nature Conservancy prepared the map.

Data analysis

Avian population trends and grazing treatments.—To determine the effectiveness of the experimental treatments and investigate general avian community trends, we compared the impact of full vs. seasonal removal of cattle grazing on the recovery of avian populations following long-term management for livestock. Specifically, we compared the number of native avian observations at each site (abundance) and the number of native species observed at each site (species richness) over the six years of data collection. We also analyzed the change in nonnative avian species and Brown-headed Cowbird abundance over the six study years. We collected the native and nonnative species measurements for the analyses at the 45 full-exclusion sites and 33 seasonal-exclusion sites, for a total of 78 sites at Garzas and Orestimba Creeks. All data reported in *Results* are means $\pm$ SE.

For the overall abundance comparison between experimental treatments, we used model fitting to create generalized estimating equations (Liang and Zeger 1986, Zeger and Liang 1986, Diggle et al. 2002). For this analysis, we used the Geese Package in R with an

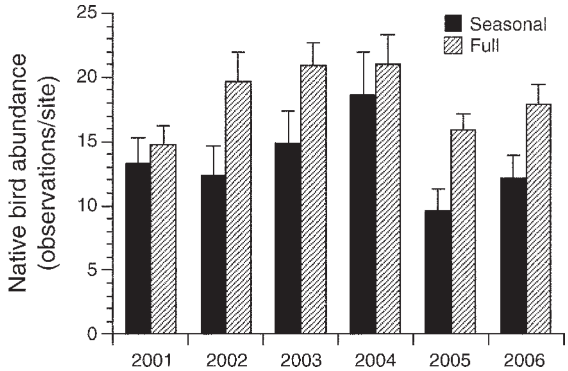

FIG. 2. Abundance of native birds (mean + SE) in sites with seasonal vs. full livestock exclusion. Data were collected at the Simon Newman Ranch from 2001 to 2006, where 2001 is the pretreatment measurement.

autoregressive correlation structure, and statistical significance at the $\alpha = 0.1$ level. With SPSS, we then used the repeated-measures analysis of variance (ANOVAR) to determine if temporal trends in avian abundance and richness differed between the full- and seasonal-exclusion treatments. Data that were not normally distributed were log-transformed to meet this statistical assumption. In some cases, we applied the Huynh-Feldt correction to address violated Mauchly's sphericity conditions. The model-fitting and repeated-measures analyses incorporated baseline conditions.

Avian species composition.—To further investigate additional trends in the avian data set, we applied multivariate statistical analyses using the PRIMER package (Clarke and Gorley 2001). We used similarity percent analyses (SIMPER; Clarke 1993) to determine which bird species were contributing to the majority of the overall abundance annually for both the seasonal- and full-exclusion treatments. We used this information to compare species composition between the two livestock exclusion treatments.

Breeding Bird Survey.—We also compared the study's avian abundance results to California avian data from the U.S. Geological Survey (USGS) Breeding Bird Survey (BBS), to determine if the study's trends were due to the treatments or to regional changes in bird populations. The Breeding Bird Survey database is commonly used for these types of comparisons (Gardali et al. 2006). We looked at the overall native bird abundance trends in the study and compared this to BBS trends for the same species for all of the routes in California. We selected all of the routes in California, rather than specific regions, to minimize experimental error by having a larger sample size. Specifically, we looked to see if regional bird populations were stable, decreasing, or increasing during the study period, and if these populations had any dramatic shifts in abundance. This comparison allowed us to verify treatment effects and explain certain annual fluctuations in avian population abundance.

RESULTS

Avian population trends and grazing treatments

In total, there were 87 native avian species at the point count stations during the six years of experimental observation. Overall, there was a significantly higher abundance of native birds in non-grazed, full-exclusion stations (no cattle) compared to seasonally grazed stations (Fig. 2). Specifically, the seasonal-exclosure stations had a 29% lower average avian abundance (total abundance averaged per point count station) compared to the full-exclosure stations (CI 90%; 17–35%). For both treatments, avian abundance generally increased over time through 2004, following the full or partial removal of cattle (Fig. 2; $P < 0.001$). Contrast results show that native avian abundance in the baseline year, 2001, was significantly different from that in 2002, 2003, 2004, and 2006. There were no significant interaction effects between the grazing treatment and time ($P > 0.05$), nor were either of the covariates, temperature and wind, significant. Native species richness did not differ between the grazing treatments (ANOVAR; $P = 0.105$), although avian richness did increase over time through 2004 for both treatments (Fig. 3; ANOVAR; $P < 0.001$). There were also significant differences in native species richness between 2001 and the following years: 2003, 2004, and 2006.

Although there was a general increase in native species abundance, nonnative species and nest parasite abundance increased as well. We observed three nonnative bird species at the point count stations: Rock Dove (*Columba livia*), House Sparrow (*Passer domesticus*), and European Starling (*Sturnus vulgaris*). Nonnative species abundance increased significantly over time ($P = 0.003$) in both the seasonal and full livestock exclusion treatments through 2003, with a higher abundance of birds in the full-exclusion areas (Fig. 4; ANOVAR; $P < 0.001$). The brood parasite,

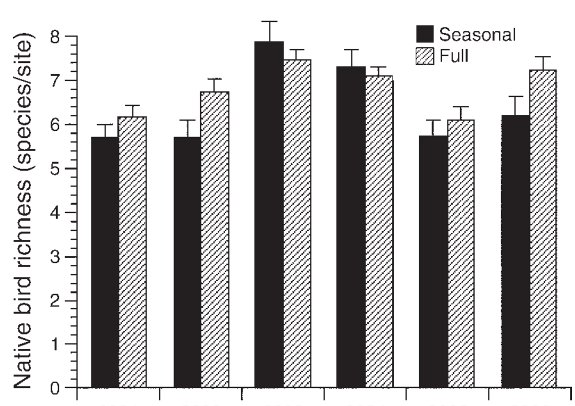

FIG. 3. Native species richness (mean + SE) at seasonal and full livestock exclosure study sites, from 2001 to 2006; 2001 is the baseline year and 2002–2006 are the posttreatment measurements.

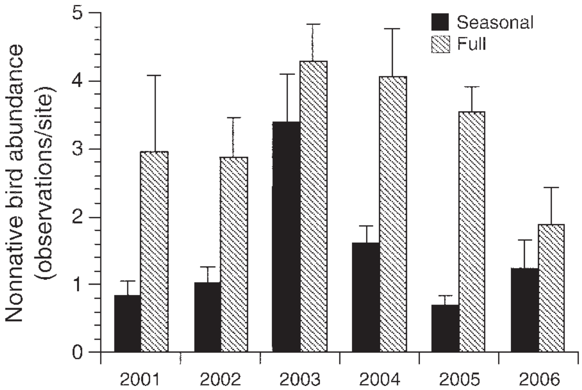

FIG. 4. Abundance of nonnative birds (mean + SE) in seasonal and full livestock exclosure sites; 2001 is the pretreatment measurement and 2002–2006 are the posttreatment measurements.

Brown-headed Cowbird (*Molothrus ater*), was more dense in the full-exclusion treatments ($P < 0.001$) and significantly increased through 2004 (Fig. 5; ANOVAR; $P = 0.015$). Bird species that host the Brown-headed Cowbird were also more abundant in full-exclusion treatments ($P < 0.001$), but only increased initially, with a decline in abundance following 2002 and a greater increase over time with full livestock removal (Fig. 5; ANOVAR; $P = 0.03$).

Avian species composition

For each of the study years, 9–13 avian species accounted for 90% of the total annual abundance (SIMPER; Clarke 1993). Overall, the species composition of study years 2001 and 2006 was the least similar (average dissimilarity = 74.54). Of the species that made up the majority of abundance annually, the following five were dominant in all of the study years: Killdeer (*Charadrius vociferous*), Brewer's Blackbird (*Euphagus cyanocephalus*), Brown-headed Cowbird, Western Kingbird (*Tyrannus verticalis*), and Mourning Dove (*Zenaida macroura*) (Table 1). Three other species contributed to 90% of the total abundance in five years, including Red-winged Blackbird (*Agelaius phoeniceus*) and Bullock's Oriole (*Icterus bullockii*) in all years except the baseline year (2001), and Western Meadowlark (*Sturnella neglecta*) in all years except 2005 (Table 1).

Comparing the dominant species annually between the full- and seasonal-exclusion treatments, a greater number of total species contributed to 90% of the total abundance during the study period in the seasonal-exclosure than in the full-exclosure areas. There were 27 dominant species in the seasonal-exclosure stations, compared to 10 dominant species in the full-exclosure stations from 2001 to 2006 (Table 1). Of the seasonal-exclosure dominant species, only 15% were found in all six years, including: Oak Titmouse (*Baeolophus inornatus*), Killdeer, Brewer's Blackbird, and Mourning Dove (Table 1). For the full-exclosure dominant species, 50% were found in all six years, and included: Brewer's Blackbird, Brown-headed Cowbird, Western Meadowlark, Western Kingbird, and Mourning Dove (Table 1).

Comparison with the Breeding Bird Survey

In the study, the general trend over time was an increase in bird abundance from 2001 to 2004, with a decline in 2005 and an initial recovery in 2006 (Fig. 6). Regional trends for the same species were different compared to the study populations. These species, surveyed in the Breeding Bird Survey for California, were relatively constant from 2001 to 2004, declining in 2005 and increasing in 2006 (Fig. 6).

DISCUSSION

We observed a general increase in native avian abundance and richness for both the non-grazed and seasonally grazed areas. Native birds, however, responded more positively to the complete removal of cattle compared to seasonal exclusion. This is consistent with other studies, where the complete removal of cattle resulted in greater avian species recovery than in areas that continued to be grazed (Dobkin et al. 1998, Popotnik and Giuliano 2000, Tewksbury et al. 2002, Martin and McIntyre 2007). Avian populations responded within one year to grazing removal, which may

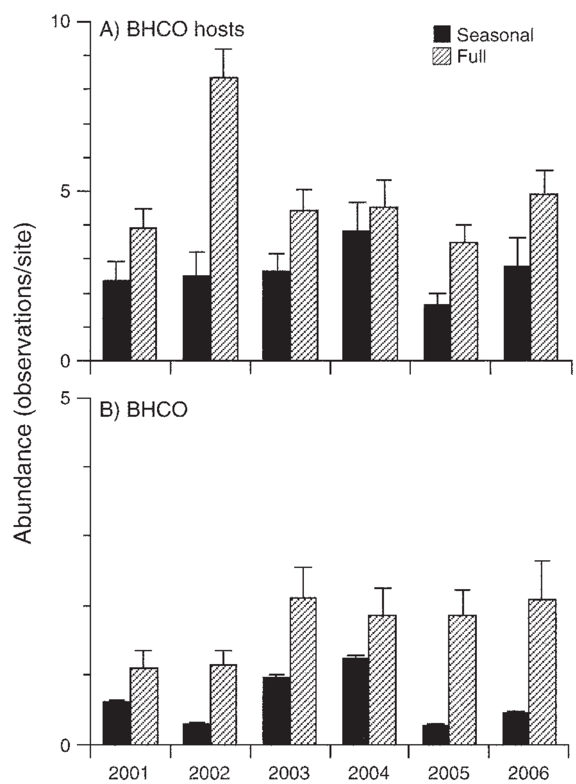

FIG. 5. Abundance (mean + SE) of (A) hosts of Brown-headed Cowbird (BHCO) and (B) Brown-headed Cowbirds in seasonal and full livestock exclosure sites; 2001 is the baseline year and 2002–2006 are the posttreatment measurements.

TABLE 1. Number of species and percentage contribution for each of the avian species contributing to 90% of the total abundance during the six study years.

Year	No. species	Dominant species
a) Full-exclosure dominant species, 2001–2006		
2001	7	**BRBL** (23.8%), **WEME** (14.5%), **WEKI** (13.3%), **MODO** (12.9%), KILL (12.4%), YBMA (8.5%), **BHCO** (5.6%)
2002	9	RWBL (24.9%), **BRBL** (13.5%), **WEME**(9.3%), **MODO** (10.7%), YBMA (8.3%), **BHCO** (7.9%), KILL (7.8%), **WEKI** (7.6%), HOFI (3.5%)
2003	8	**WEKI** (24.6%), RWBL (16.1%), BUOR (12.8%), KILL (11%), **BHCO** (10%), **MODO** (9.7%), **WEME** (5.6%), **BRBL** (3%)
2004	10	**WEKI** (23.4%), **MODO** (16.1%), BUOR (9.6%), **WEME** (9%), RWBL (7.8%), **BHCO** (7.6%), **BRBL** (5.4%), YBMA (4.9%), KILL (4.8%), HOFI (3.2%)
2005	8	**WEKI** (35.5%), **BHCO** (15%), **MODO** (12.2%), RWBL (8.4%), BUOR (7.7%), **BRBL** (4.5%), HOFI (4.0%), **WEME** (3.9%)
2006	9	**MODO** (19.3%), **WEKI** (15.1%), **BCHO** (12.5%), RWBL (11.9%), **WEME** (9.6%), KILL (6.8%), **BRBL** (6.6%), BUOR (5.2%), HOFI (4.7%)
b) Seasonal-exclosure dominant species, 2001–2006		
2001	10	**MODO** (22.3%), YBMA (16.1%), BHCO (9.5%), CAQU (9.5%), **BRBL** (8.1%), CORA (7.1%), WEKI (6.9%), **OATI** (6.3%), RWBL (3.6%), **KILL** (3.1%)
2002	15	YBMA (22.7%), **BRBL** (12.2%), **OATI** (10.6%), **MODO** (8.5%), **KILL** (5.6%), ORJU (4.6%), BUOR (4.5%), CAQU (4.2%), HOFI (4.1%), CBCH (3.2%), WEKI (2.5%), AMCR (2.3%), WESJ (2.3%), CORA (2.1%), WCSP (2.0%)
2003	14	**BRBL** (14.2%), **MODO** (11.2%), **KILL** (10.7%), BHCO (9.8%), WEKI (8.7%), **OATI** (8.2%), BUOR (6.7%), ATFL (5.1%), AMCR (4.8%), CAQU (3.6%), LEGO (2.2%), YBMA (2.0%), RWBL (1.9%), CLSW (1.8%)
2004	14	**OATI** (19.2%), BHCO (12.7%), **MODO** (11.8%), AMCR (10.8%), WEKI (8.6%), **KILL** (7.3%), RWBL (3.5%), **BRBL** (3.4%), AMGO (2.9%), WBNU (2.6%), NUWO (2.2%), BEWR (2.1%), CLSW (2.0%), CORA (1.8%)
2005	10	**OATI** (23.2%), CAQU (16.9%), **MODO** (11.4%), ATFL (9.8%), YBMA (6.8%), CORA (6.4%), **BRBL** (5.6%), RWBL (4.5%), **KILL** (2.8%), BHCO (2.5%)
2006	16	**BRBL** (10.2%), CAQU (9.4%), CORA (8.4%), AMCR (8.3%), AMKE (7.9%), BHCO (6.9%), **MODO** (6.4%), **OATI** (5.5%), WEME (5.5%), CLSW (4.3%), RWBL (4.3%), AMGO (3.9%), **KILL** (3.1%), HOFI (2.4%), LEGO (2.3%), CAWR (2.2%)

Notes: Results are from the similarity percentage analyses (SIMPER; Clarke 1993). See Appendix for full species names for each species code. Boldface indicates species found in all six study years for a given treatment, full or seasonal exclosure.

reflect the associated increase in riparian plant abundance, as was the case in other studies (Dobkin et al. 1998, Krueper et al. 2003). Over time, the birds continued to benefit from both reduced or removed cattle grazing and, potentially, the benefits of improved food and nesting resources due to increased plant structure and abundance, as well as decreased trampling, erosion, and nest predation. These benefits may be lower in the seasonally grazed treatments, where avian abundance did not increase as rapidly compared to full-exclusion treatments. Stanley and Knopf (2002) state that while late-season grazing allows for avian restoration, the recovery time may be longer than without cattle grazing. This seemed to be the case in our study, where the presence of cattle resulted in relatively slower increases in bird abundance over time. These results may have been due to continued (although lessened) impacts on soil quality, nutrient cycling, and other factors that affect plant recruitment and growth. It is interesting to note, however, that the seasonal-exclosure areas had more species that contributed to overall abundance than did the full-exclosure areas. Although Martin and McIntyre (2007) observed that species composition differs between grazing levels, it is surprising that there were more dominant species in the seasonally grazed areas and no significant difference in native species richness between grazing treatments. There are many possible ecological explanations for this result. There may have been increased competition for food and nesting resources in these areas due to grazing, which decreased the competitive advantage of certain dominant avian species. Alternatively, seasonal grazing may have provided an intermediate disturbance that created additional ecological niches and allowed for more species to dominate the bird population numbers.

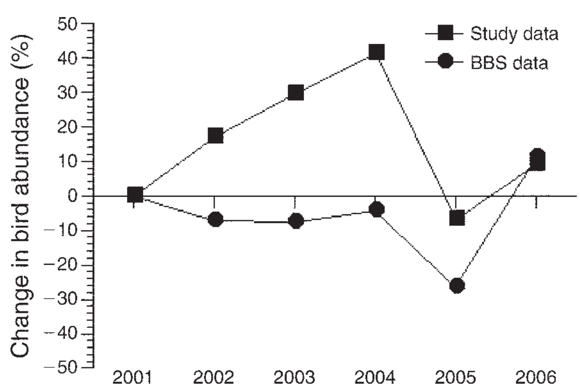

FIG. 6. Comparison of change in avian abundance for native species from the baseline year (2001) to subsequent years. The study data points represent the mean change in abundance (%) at each site for both seasonal- and full-exclusion sites. Regional data (USGS Breeding Bird Survey, BBS) are a measure of mean change in abundance across all California survey routes.

We also expected that a slower increase in avian abundance in seasonal treatment areas may be associated with other factors such as increases in nonnative species or brood parasites in the more altered habitat. Other studies have found that higher nest mortality, brood parasitism, and nonnative species presence are all related to grazing and human-altered habitats (Dobkin et al. 1998, Saab 1999, Fondell and Ball 2004). However, while we observed increases in nonnative birds and brood-parasitic Brown-headed Cowbird populations in both treatments, this was actually more pronounced in the full-exclusion areas. In some cases, the magnitude of the nonnative species abundance increase appeared greater than that of native species in the full-exclosure areas. Therefore, this is unlikely to explain lower native avian abundance in the seasonally grazed areas. Nonnative birds and the brood parasitic Brown-headed Cowbirds probably benefited from the same conditions, created by partial or full removal of livestock, as did the native birds. The Brown-headed Cowbird could have benefited from both treatment areas, using grazed habitat for foraging and ungrazed habitat for brood parasitism (Tewksbury et al. 2002). Cowbird abundance increased from 2002 to 2003, primarily in the full-exclusion areas, which corresponds to an increase in cowbird host populations from 2001 to 2002, also in full-exclusion areas. It was not unexpected that cowbird hosts declined substantially following this increase in cowbird abundance.

Other factors may have affected the changes in avian populations over time and their recovery from livestock removal. Avian abundance trends during the study period are primarily related to the full or partial removal of cattle, but the drop in both treatments during the 2005 season is best explained by regional factors through the Breeding Bird Survey (BBS) comparison. Although avian populations throughout California were relatively constant during the years of 2001–2004, the avian study populations increased in abundance during these years, which reflects a treatment effect from grazing removal. In both cases, however, abundance dropped substantially in 2005, indicating a regional source of this decline such as weather. Avian species abundance and composition is linked to general weather trends and, more specifically, to variation in precipitation, with fewer birds found in drier years (Gaines 1974, Dobkin et al. 1998, Jackson and Allen-Diaz 2006). This may explain the decrease in California bird populations in 2005. Additional factors could have influenced avian population changes following the full or partial removal of cattle, including surrounding landscape features, invasive plant species abundance and composition, adjacent vegetation quality, and riparian corridor width (Saab 1998, Bengsen and Pearson 2006).

Management implications and conclusions

Over the short term, the complete removal of livestock grazing from riparian habitats is the most rapid method for recovery of bird populations. However, seasonal grazing during the winter months also results in increased avian abundance and richness and may simply require more time for riparian habitat recovery to support bird populations equivalent to complete cattle exclusion. There probably will be additional responses of bird populations to both seasonal and full grazing removal as these areas continue to recover, especially given the relatively short-term duration of this study following a long history of grazing impacts. Land managers concerned primarily with avian restoration should remove cattle from riparian areas to maximize recovery, at least initially, to support bird populations and system function within a natural range of variability. However, they should also consider indirect, complex, and unanticipated effects of complete cattle exclusion, including potential increases in less desired bird species such as nonnative birds and brood parasites. In this case, having cattle present seasonally may be beneficial, to keep the nonnative and brood parasite numbers lower. For management situations where allowing some livestock grazing is desired or avian recovery can occur more slowly, our study demonstrates that the timing of cattle presence in riparian areas can effectively allow for both grazing interests and recovery of bird populations. This approach may also be applied across working landscapes with important bird populations and habitats, where complete livestock removal may be unrealistic. Ultimately, as land resources and riparian habitat continue to decline, finding solutions for both land use and conservation interests is critical for the success of avian conservation.

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APPENDIX

List of bird species observed at the 78 study sites at the Simon Newman Ranch, California between 2001 and 2006 (*Ecological Archives* A021-029-A1).