Point Blue
Conservation
Science

Assessing the environmental trade-offs of greenhouse gas emission reduction in California's rice fields:

The effect of baling on waterbird use of winter flooded rice fields

Interim Sub-report

Kristin A. Sesser, Khara M. Strum, Catherine M. Hickey, Matthew E. Reiter

Prepared For the Environmental Defense Fund

November 26, 2013

ABSTRACT

The post-harvest flooding of over 140,000 ha of rice fields during winter (November – February), primarily to promote decomposition of residual straw, provides 85% of the wetland habitat in the Sacramento Valley of California. Flooding of post-harvest rice fields provides essential waterbird habitat but also contributes to greenhouse gas (GHG) emissions. Recent efforts to develop practices that reduce GHG emissions within the context of rice production indicate that removal of rice straw via baling may be effective. To assess one potential environmental trade-off of this practice, we examined the effects of baling on waterbird use of rice fields in winter by surveying waterbirds and comparing densities in flooded rice fields that were either baled or not baled. We found higher shorebird (12 times) and dabbling duck (seven times) densities in fields that were not baled compared to those that were baled. We did not find that densities of long-legged waders differed between baled and non-baled fields. These preliminary results suggest that baling rice straw may reduce shorebird and dabbling duck use of winter flooded rice fields.

INTRODUCTION

The Central Valley of California is an internationally important area for migratory waterbirds in the Pacific Flyway. The Central Valley has lost 90% of its original natural wetlands, largely to agriculture and urbanization (Frayer et al. 1989), yet nearly three million ducks, one million geese and 350,000 shorebirds overwinter in this region (Shuford et al. 1998, Collins et al. 2011). Many of the 4.3 million waterbirds that overwinter in the Central Valley use the northern extent known as the Sacramento Valley where winter flooding of over 140,000 ha of rice fields provides 85% of the flooded habitat in the region (CVJV 2006). Current post-harvest management of rice fields benefits both farmers and wildlife, particularly winter flooding, which increases the decomposition of rice straw and provides flooded habitat for over 30 species of waterbirds during the winter (Day and Colwell 1998, Elphick and Oring 1998, Strum et al. 2013).

Like other agricultural sectors, rice production both emits and sequesters greenhouse gases (GHG). State regulations enacted in the 1990s restricted the amount of allowable straw burning (Rice Straw Burning Act, AB 1378 1991) and caused an increase in the amount of rice that is winter-flooded for straw decomposition. This transition from burning to flooding for post-harvest straw management has resulted in reductions in pollutant emissions but has increased GHG emissions. The by-product of straw decomposition via flooding and subsequent fermentation is methane, which is a 20 times more potent GHG than carbon dioxide, the by-product of burning rice straw. Recent efforts to implement and study practices that reduce GHG emissions within the context of rice production have identified that removal of rice straw via baling prior to flooding produces lower GHG emissions than an identified baseline (EDF 2010).

Understanding the impacts of GHG emissions-reducing rice field management practices on wildlife, particularly waterbirds, is important when weighing the costs and benefits of implementing these practices in order to find optimal solutions for reducing GHG emissions while continuing to support target levels of waterbird populations. Point Blue Conservation Science was contracted by the Environmental Defense Fund through a USDA Natural Resources Conservation Service Conservation

Innovation Grant to assess potential trade-offs. Although waterbird use of winter-flooded rice has been studied (Taft and Elphick 2007, Strum et al. 2013), there is little information regarding the effect of straw removal via baling on waterbird use. Herein we report on one aspect of our overall project: a study designed to compare waterbird use of winter-flooded rice fields where the straw was baled with winter-flooded rice fields where rice straw was left to decompose in the field (non-baled).

METHODS

Study area

The Sacramento Valley is located north of the Sacramento-San Joaquin River Delta in the Central Valley of California (Fig. 1). Average annual rainfall, generally falling between the months of October and February, is 51 cm. The region historically flooded in late winter creating seasonal wetlands across the valley floor. There are approximately 200,000 ha of rice in this region. The average farm size is 280 ha and the average rice field is 20–80 ha. Currently, flooded habitat is provided by 142,000 ha of winter-flooded rice and 24,000 ha of managed wetlands irrigated by a series of highly managed, interconnected canals and ditches (CVJV 2006).

Study species

Specific habitat requirements vary for each waterbird guild (e.g. shorebirds, dabbling ducks, long-legged waders) using winter-flooded rice fields of the Sacramento Valley. Shorebirds (Order: Charadriiformes; Sub-Orders: Scolopaci, Charadrii) use a relatively narrow range of water depths from mudflat to 13 cm (Elphick and Oring 1998; Strum et al. 2013). Dabbling ducks (Order: Anseriformes; Family: Anatidae; Sub-Family: Anatinae) generally use a deeper range of water depths of 14–22 cm (Elphick and Oring 1998). Long-legged waders (Order: Pelecaniformes; Family Ardeidae, White-faced Ibis [*Plegadis chihi*] and Sandhill Crane [*Grus canadensis*]) have less restrictive in-field habitat requirements and use a diverse variety of habitats including vegetated and open, flooded and non-flooded (Tacha et al. 1992, Ryder and Manry 1994, McCrimmon et al. 2001, Strum et al. 2013).

Field treatments

After harvest, there is usually 2–3 feet of standing rice straw left in a field. Baling is the removal of this excess plant material and is performed soon after harvest. Baled fields can either be left until spring, or the remaining stubble (2–6 inches) can be incorporated into the soil and/or the field can be flooded. Non-baled fields contain excess straw that is normally incorporated using a disk or chisel and/or flooded post-harvest, but can also be left standing. Post-harvest flooding of rice fields occurs immediately after to several weeks after harvest. The two treatments in this study were baled and non-baled flooded fields.

Study design

We opportunistically contacted rice growers with either treatment in an effort to achieve a spatially balanced distribution of both treatments throughout the Sacramento Valley. Within farms, rice fields are divided into subunits called paddies, separated by internal earthen levees. We considered the individual paddy to be the sample unit. We selected survey points on our participating farms using Generalized Random Tessellation Stratified sampling methodology, which enabled the selection of spatially balanced random locations with respect to treatment and region (Stevens and Olsen 2004). The number of sample units in each treatment varied among farms.

Data collection

We conducted waterbird surveys from a pre-determined point at the edges of selected paddies, and defined the outer bound of the survey area within a paddy using a 200 m fixed-radius. Each selected paddy only contained one survey point. Each point was surveyed every 10 days (for a total of 5 surveys of each point during the study). We conducted surveys from 2 December 2011 to 27 January 2012 (Year 1) and from 3 December 2012 to 27 January 2013 (Year 2). In Year 1, we surveyed 99 points (45 baled, 54 non-baled) at 11 rice farms and in Year 2, we surveyed 137 points (65 baled, 72 non-baled) at 13 rice farms. We varied the order in which we surveyed points to avoid bias in counts attributable to the time of day. We identified all birds within 200 m of the point to species and counted all individuals. At each point, we scanned the survey area within the paddy for at least two minutes. There was no maximum time limit for completing a count; the survey was complete once all birds in a survey area were enumerated or after two minutes of scanning. We only counted birds using the survey area, and did not count birds that flew over the survey area. Surveys were not conducted in inclement weather, i.e. winds ≥ 40 kph, heavy fog, or rain.

Data analysis

Because not all paddies extended 200 m from the survey point and paddies vary in width, we calculated the area (ha) surveyed at each sample point using ArcMap Version 9.3.1 (© 1999-2009 ESRI Inc.). We estimated mean waterbird density (birds/ha) for each guild in each treatment and compared them using 95% confidence intervals (95% CI). Due to the large number of zeros and non-normal distribution of bird counts and subsequently bird density, we used bootstrapping and the percentile method to estimate the 95% CI for the density estimates of each guild (Manly 2007). We considered density estimates to be significantly different if their 95% CI did not overlap. All analyses were conducted in the statistical program R version 2.13.0 (R Core Development Team 2011).

RESULTS

We observed a total of 30 species of waterbirds representing three guilds (Table 1); shorebirds, dabbling ducks, and long-legged waders. Shorebirds and dabbling ducks were more abundant in the non-baled fields than in baled fields. For both years combined, mean shorebird density was significantly higher (12 times) in the non-baled fields than the baled fields (Fig. 2). Shorebird densities were higher in non-baled fields than baled fields in both years, but not significantly so in year 2. Similarly, for both years combined, mean dabbling duck density was significantly higher (seven times) in the non-baled fields than the baled fields (Fig. 2). However, there were no significant differences between treatments in either year alone.

The differences in the mean density of long-legged waders between treatments were not as clear (Fig. 2). One baled field on one farm continually hosted a large flock (>1000) of White-faced Ibis during Year 1, but not Year 2. Because this flock was so large compared to other flocks of long-legged waders, with this species included in the analysis, variation around the mean estimate for this guild was extremely large. Hence we present the results for the long-legged wader guild with and without White-faced Ibis. For both years combined, there was no significant difference between treatments in long-legged wader density, with or without White-faced Ibis. In Year 1, mean density (without White-faced Ibis) was significantly higher in non-baled fields (five times) than in baled fields. The inclusion of White-faced Ibis reverses this pattern in Year 1; however the difference between treatments was not significant.

CONCLUSIONS AND NEXT STEPS

Our preliminary results indicate that baling rice straw may reduce the number of shorebirds and dabbling ducks that use winter-flooded rice fields. In contrast, we did not find evidence that baling affects long-legged wader use of winter-flooded rice fields. The long-legged wader guild includes species from several different taxonomic groups (herons and egrets, ibis, and cranes) that use a larger diversity of habitats. Further analyses and modeling may elucidate differential patterns by species within guilds.

Our next steps are to incorporate into this report the final results of (1) the effects of post-harvest baling on the availability of waste rice and the presence of invertebrates and seeds and (2) the effects of drill-seeding on waterbird use of rice fields in spring. We will also use multivariate regression models to assess other covariates that may be associated with the use of fields by waterbirds (e.g. incorporation versus non-incorporation) or that are likely correlated with post-harvest treatment and thus provide a more mechanistic understanding of the bird-habitat relationship (e.g. food availability). Previous studies suggest the method of post-harvest treatment in rice fields may influence use by shorebirds and waterfowl (Elphick and Oring 1998). Baled fields in our study were less likely to have stubble straw incorporated than non-baled fields; 52.7% of baled survey points had stubble straw incorporated compared to 90.5% of non-baled points, thus we think this is an important covariate to consider.

Waterbird density data will then be used in the final component of the project to identify optimal treatment allocation to meet shorebird, dabbling duck, and long-legged wader population objectives while minimizing GHG emissions. A final report will be complete by July 2014.

LITERATURE CITED

Collins, D. P., C. A. Palmer, and R. E. Trost. 2011. Pacific Flyway Data Book 2011: Waterfowl harvests and status, hunter participation and success in the Pacific Flyway and United States. U. S. Fish and Wildlife Service Division of Migratory Bird Management, Portland, Oregon.

CVJV. 2006. Central Valley joint venture implementation plan—conserving bird habitat. U.S. Fish and Wildlife Service, Sacramento, CA.

Day, J. H. and M. A. Colwell. 1998. Waterbird communities in rice fields subjected to different post-harvest treatments. Colonial Waterbirds 21:185–197.

Elphick, C. S. and L. W. Oring. 1998. Winter management of Californian rice fields for waterbirds. Journal of Applied Ecology 35:95–108.

EDF. 2010. Creating and quantifying carbon credits from voluntary practices on rice farms in the Sacramento Valley: accounting for multiple benefits for producers and the environment. Report to the USDA Natural Resources Conservation Service. Environmental Defense Fund, Inc., Sacramento, California, 54 pp.

Frayer, W. E., D. D. Peters, and H. R. Pywell. 1989. Wetlands of the California Central Valley: Status and Trends - 1939 to mid-1980s. U.S. Fish and Wildlife Service, Region 1, Portland, Oregon, 28 pp.

Manly, B. F. 2007. Randomization, bootstrap, and Monte Carlo methods in biology. Chapman and Hall, Boca Raton, Florida, USA.

McCrimmon, Jr., D. A., J. C. Ogden and G. T. Bancroft. 2011. Great Egret (*Ardea alba*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/570

McNeil, R., P. Drapeau, and J. D. Goss-Custard. 1992. The occurrence and adaptive significance of nocturnal habits in waterfowl. Biological Reviews. 67:381–419.

R Core Development Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available: http://www.R-project.org/ (June 2012).

Ryder, R. A. and D. E. Manry. 1994. White-faced Ibis (*Plegadis chihi*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/130

Shuford, W. D., G. W. Page, and J. E. Kjelmyr. 1998. Patterns and dynamics of shorebird use of California's Central Valley. Condor. 100:227–244.

Stevens, D. L. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association. 99:262–278.

Strum, K. M, M. E. Reiter, C. A. Hartman, M. N. Iglecia, T. R. Kelsey, C. M. Hickey. 2013. Winter management of California’s rice fields to maximize waterbird habitat and minimize water use. Agriculture, Ecosystems, and Environment. 179:116–124.

Tacha, T. C., S. A. Nesbitt and P. A. Vohs. 1992. Sandhill Crane (*Grus canadensis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/031

Taft, O. W. and C. S. Elphick. 2007. Waterbirds on working lands: literature review and bibliography development. Technical Report. National Audubon Society, New York, New York. http://www.audubon.org/bird/waterbirds/downloads.html, accessed January 10, 2009.

Table 1. Waterbird abundance in two flooded post-harvest rice field treatments surveyed during two winters, December 2, 2011 – January 27, 2012 (Year 1) and December 3, 2012 – January 25, 2013 (Year 2) in the Sacramento Valley, CA.

Guild	Common name	Baled	Non-baled
Dabbling ducks	Wood Duck	1	0
	Gadwall	0	52
	Eurasian Wigeon	0	2
	American Wigeon	20	277
	Mallard	21	232
	Northern Shoveler	150	638
	Northern Pintail	808	5624
	Green-winged Teal	12	1174
	Mixed Ducks	0	600
Long-legged Waders	Great Blue Heron	31	32
	Great Egret	27	36
	Snowy Egret	6	8
	White-faced Ibis	2785	205
	Sandhill Crane	27	157
Shorebirds	Black-bellied Plover	6	5
	Killdeer	279	392
	Black-necked Stilt	18	0
	Greater Yellowlegs	40	171
	Lesser Yellowlegs	0	1
	Long-billed Curlew	3	159
	Sanderling	0	1
	Western Sandpiper	0	3
	Least Sandpiper	61	1867
	Dunlin	223	4885
	Dowitcher spp.	5	1102
	Wilson's Snipe	20	81

Figure 1. Locations of rice farms surveyed for waterbirds from December 2, 2011 – January 27, 2012 (Year 1) and December 3, 2012 – January 25, 2013 (Year 2) in the Sacramento Valley, CA.

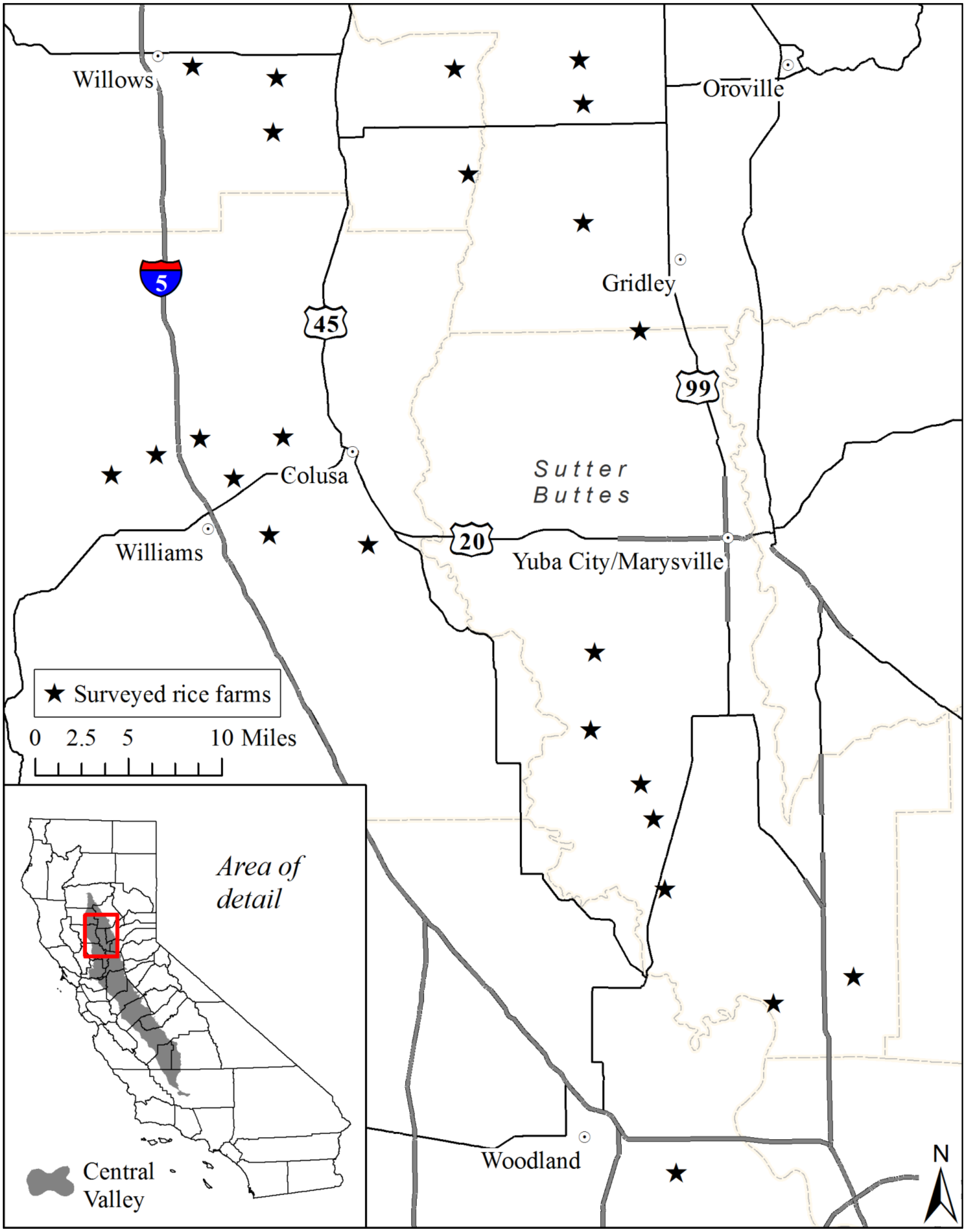

Figure 2. Mean waterbird density (birds/ha) and 95% confidence intervals in two flooded post-harvest treatments, baled and non-baled, surveyed from December 2, 2011 – January 27, 2012 (Year 1) and December 3, 2012 – January 25, 2013 (Year 2) in the Sacramento Valley, CA. Note the difference in scale of the y-axis, especially for the long-legged wader guild.