Biological Conservation 197 (2016) 69–79

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/bioc

Waterbird response to management practices in rice fields intended to reduce greenhouse gas emissions

Kristin A. Sesser *, Matthew E. Reiter, Daniel A. Skalos [1], Khara M. Strum [2], Catherine M. Hickey

Point Blue Conservation Science, 3820 Cypress Drive Suite 11, Petaluma, CA 94954, USA

ARTICLE INFO

Article history:
Received 29 July 2015
Received in revised form 18 February 2016
Accepted 22 February 2016
Available online 12 March 2016

Keywords:
Waterbirds
California
Rice
Greenhouse gas
Baling
Drill seeding

ABSTRACT

There are many benefits of agricultural landscapes for wildlife. In California's Central Valley, post-harvest flooding of rice fields increases the decomposition of rice stubble and provides habitat for over 50 species of waterbirds. These fields are also flooded during planting, providing habitat for spring migrants and locally breeding birds. Because California has lost over 90% of its historic wetlands, flooded rice is critical wildlife habitat, providing 80% of the total flooded habitat in the Sacramento Valley. Flooding rice fields, however, contributes to greenhouse gas (GHG) emissions. Several rice field management practices may reduce methane emissions including reduced flooding in winter, removal of rice straw after harvest (baling), and drill seeding during planting. During the winters of 2011–2012 and 2012–2013, we compared waterbird use in four combinations of post-harvest practices: baled/flooded, baled/non-flooded, non-baled/flooded, and nonbaled/non-flooded. We found significantly higher dabbling duck and shorebird densities in the non-baled/flooded practice compared to the other three practices. During the spring of 2012 and 2013, we compared waterbird use of drill-seeded fields (reduced GHG) with flooded fly-on seeded fields (status quo GHG). We found no significant differences in mean density between the two seeding practices for waterbirds. Our study found evidence that some post-harvest practices (reduced winter flooding, baling) that reduce GHG emissions from rice also reduce use by waterbirds. While reducing GHG is globally necessary to minimizing the impacts of climate change, doing so in an area of hemispheric importance for waterbirds should be done with caution.

1. Introduction

The predicted impacts of climate change on wildlife and biodiversity are many (Bellard et al., 2012). Reducing greenhouse gas (GHG) emissions is necessary to minimize those impacts (IPCC, 2014). Agriculture contributes 10–12% of global anthropogenic GHG emissions and accounts for 52% of global anthropogenic methane (CH_4) emissions (Smith et al., 2007). Methane is a powerful GHG, 25 times more potent than carbon dioxide (CO_2). Rice agriculture contributes 5% of global methane emissions (Smith et al., 2007), and <1% of United States methane emissions (US-EPA, 2015). Rice agriculture is also recognized globally and nationally as important habitat for waterbirds (Stafford et al., 2010; Eadie et al., 2008). So, while reducing GHG emissions is globally necessary, practices that reduce GHG emissions from rice fields should be evaluated for the unintended consequence of reducing the quantity or quality of wildlife habitat.

In some regions of the world where wetland habitat loss is extensive, rice fields provide important alternative wetland habitat for waterbirds (Fasola and Ruiz, 1996; Elphick, 2000). This is especially true in California's Central Valley, where 90% of the original natural wetlands have been lost, primarily to agriculture and urbanization (Frayer et al., 1989). Despite this loss of wetlands, nearly three million ducks, two million geese, and 350,000 shorebirds continue to overwinter in this region (Shuford et al., 1998; Olson, 2014), making the Central Valley an internationally important area for migratory waterbirds in the Pacific Flyway (Gilmer et al., 1982; WHSRN, 2003). A large proportion of these birds rely on flooded rice fields, which provide habitat for over 50 species of waterbirds during the non-breeding (Day and Colwell, 1998; Elphick and Oring, 1998) and breeding seasons (Eadie et al., 2008; Shuford et al., 2007).

Flooded rice fields generate GHGs because methane is produced by microbial decomposition of organic material in oxygen-deprived, flooded conditions (Mosier et al., 1998), which occur both during the growing and post-harvest seasons. During the growing season, methane emissions can be reduced in several ways, most of which involve drying the soils periodically. Recent work in California identified two practices with potential to decrease methane emissions during this time: drill seeding (planting

* Corresponding author.
E-mail address: ksesser@pointblue.org (K.A. Sesser).
[1] Present address: California Department of Fish and Wildlife, 1812 9th Street, Sacramento, CA 95811, USA.
[2] Present address: Audubon California, 400 Capitol Mall Suite 1535, Sacramento, CA 95814, USA.

http://dx.doi.org/10.1016/j.biocon.2016.02.021

seeds into a dry field) and periodic draining of fields during the summer growing season. Drill seeding, which we address here, has the potential to reduce methane emissions by 16% (EDF, 2011) over the traditional flooded fly-on seeding. During the non-growing season, methane emissions can be reduced by keeping the soils as dry as possible (Kang et al., 2002; Xu et al., 2003) and by adjusting the timing or amount of organic residue additions (Xu et al., 2000). Practices identified in California include reduced winter flooding and removal of rice straw after harvest via baling (Bossio et al., 1999; Suddick et al., 2010; EDF, 2011). These practices have the potential to reduce methane emissions by 13–32% on any given field over incorporating most rice residue into the soil and/or flooding post-harvest (EDF, 2011). Currently 3% of the 227,000 ha of rice grown annually in California are baled post-harvest, and approximately 47% of rice fields are flooded (Garr, 2014).

In California, agriculture contributes 8.9% of the state's anthropogenic GHG emissions and of that, rice agriculture contributes 3% (0.3% of total), most as methane during the growing season (CA-ARB, 2014). State regulations enacted in the 1990s restricted the amount of allowable rice residue burning (Rice Straw Burning Reduction Act, AB 1378, 1991) resulting in an increase in the amount of rice that is flooded after harvest for residue (straw and stubble) decomposition (Miller et al., 2010). This reduction in burning for residue management post-harvest decreased air pollution, including CO_2, but increased annual GHG emissions (Fitzgerald et al., 2000; CA-ARB, 2003) because the by-product of straw fermentation via flooding is methane.

The state of California set a target of reducing GHG emissions to 1990 levels by 2020 (Global Warming Solutions Act of 2006, AB-32, 2006). Reducing GHG emissions from agriculture will be an important component of reaching those goals. California is considering adopting some GHG emission-reducing practices for rice agriculture in its Cap-and-Trade Program (CA-ARB, 2014). While mitigation measures may help get California closer to its AB-32 goals, the practices used for mitigation could also reduce the ability of rice to provide surrogate wetland habitat for waterbirds, either by reducing the total amount of flooded habitat, or by reducing the fields' ability to provide habitat to certain groups of waterbirds (e.g., by reducing the availability of suitable water depths or other indicators of good quality habitat; see Strum et al., 2013).

We studied the response of waterbirds to rice management practices designed to reduce GHG emissions in the Sacramento Valley of California. Specifically, we compared waterbird density and other indicators of habitat quality (1) among four combinations of post-harvest management practices of flooding and baling during winter; and (2) between drill seeding and flooded fly-on seeding during spring.

2. Methods

2.1. Study area

The Sacramento Valley is the northern portion of the Central Valley of California (Fig. 1). Average annual rainfall is 51 cm and most rain falls between the months of October and February. The region historically flooded in late winter creating approximately 1.5 million ha of seasonal wetlands across the valley floor (Frayer et al., 1989). Over the last century, the majority of these historical wetlands have been converted to agriculture, with only 28,300 ha of managed wetlands remaining. Currently there are approximately 227,000 ha of rice grown in the Sacramento Valley (USDA, 2014) providing flooded habitat to spring migrants and breeding waterbirds. During winter, the amount of rice fields that are flooded decreases to approximately 107,000 ha (Garr, 2014) and provides important habitat for migratory and wintering waterbirds.

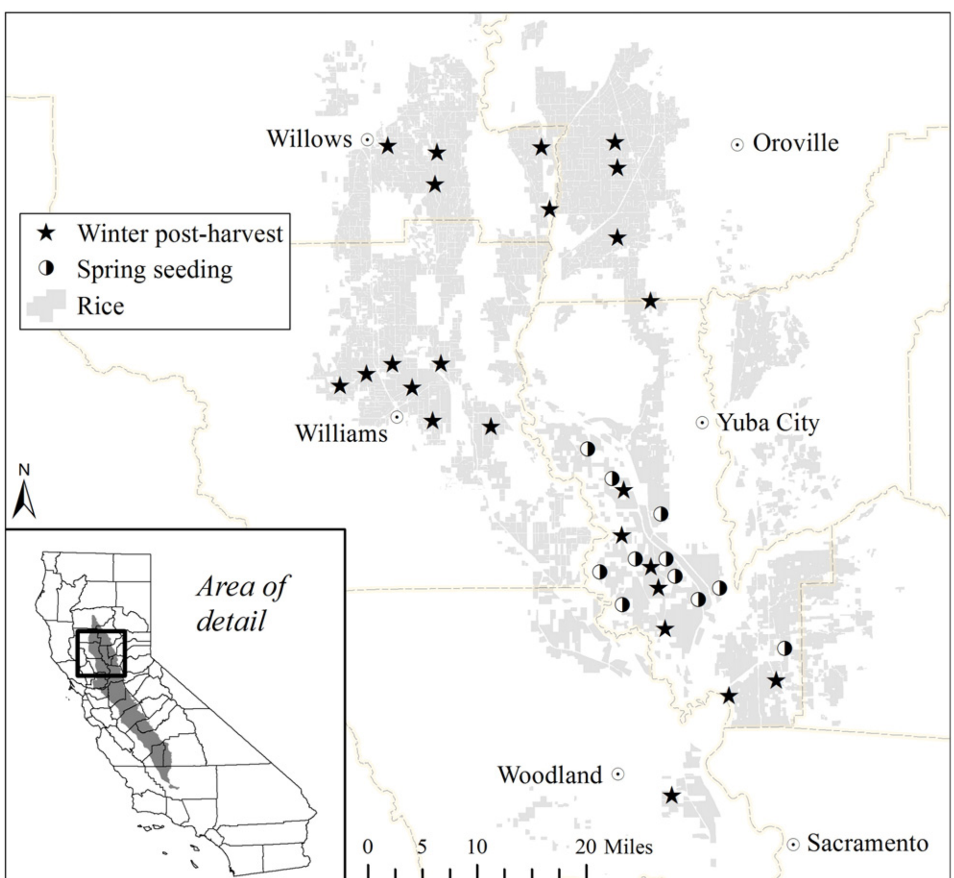

Fig. 1. Location of participating rice farms in the Sacramento Valley, California, USA for both the winter post-harvest and spring seeding studies of waterbird use of rice fields, 2011–2013.