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Original research paper

Effects of crop type and harvest on nest survival and productivity of dickcissels in semi-natural grasslands

Tara J. Conkling[a,*,1], Jerrold L. Belant[b], Travis L. DeVault[c], James A. Martin[d]

[a] Agricultural Ecology Laboratory, Forest and Wildlife Research Center, Mississippi State University, Box 9690, Mississippi State, MS 39762, USA
[b] Carnivore Ecology Laboratory, Forest and Wildlife Research Center, Mississippi State University, Box 9690, Mississippi State, MS 39762, USA
[c] United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Sandusky, OH 44870, USA
[d] Warnell School of Forestry and Natural Resources, Savannah River Ecology Lab, University of Georgia, Athens, GA 30602, USA

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ABSTRACT

Recent focus on climate change and global energy production has increased interest in developing biofuels including perennial native grasses (e.g. switchgrass [*Panicum virgatum*]) as viable energy commodities while simultaneously maintaining ecosystem function and biodiversity. However, there is limited research examining the effects of biofuel-focused grasslands on grassland bird reproductive success and conservation. In 2011–2013 we studied the effects of vegetation composition and harvest regimens of switchgrass monocultures and native warm-season grass (NWSG) mixtures on nest success, nest density, and productivity for dickcissels (*Spiza americana*) in Clay Co. MS, USA. There was no effect of vegetation metrics, harvest frequency, or biofuel treatment on nest survival. However, both vegetation composition and harvest frequencies influenced nest density and productivity. Native warm season grasses contained 54–64 times more nests relative to switchgrass treatments, and nest density and productivity were 10% greater in single harvest plots. Our results suggest semi-natural grasslands can balance biofuel production, ecosystem functionality, and conservation so that biofuels offer an opportunity for wildlife conservation rather than a continued threat to grassland birds.

1. Introduction

Biofuels are a recent focus of global energy policies aimed at reducing greenhouse-gas emissions and alleviating climate change concerns while bolstering local economies (Farrell et al., 2006; Campbell et al., 2008; Tilman et al., 2009; U.S. EPA, 2011). As such, there is increased interest in the use of perennial native grasses (e.g., switchgrass [*Panicum virgatum*]) for bioenergy production as they may also maintain ecosystem services including water and soil quality and wildlife habitat (McLaughlin and Kszos, 2005; Parrish and Fike, 2005; Fargione et al., 2009; Hartman et al., 2011; Uden et al., 2014 Fargione et al., 2009; Hartman et al., 2011; Uden et al., 2014). However, there is limited research addressing the effects of semi-natural grasslands (Allen et al., 2011) for biofuel production on the distribution, habitat selection, and demography of wildlife (Murray and Best, 2003; Allen et al., 2011; Mitchell et al., 2012; Dunlap, 2014).

Semi-natural grasslands managed for biofuels may mimic natural grasslands based on overall ecosystem functionality and vegetation structure (Fletcher and Koford, 2002), but there is ongoing debate regarding the most appropriate grass species or harvest strategies to use for energy production while maintaining biodiversity. Switchgrass monocultures often produce more cellulosic ethanol than low-input high-diversity plant mixtures because greater plant species richness decreases biofuel yield (Adler et al., 2009). However, greater structural and species heterogeneity in mixed species plantings supports greater biodiversity and ecosystem functions (Tilman et al., 2006; Adler et al., 2009; Meehan et al., 2010; Werling et al., 2014). Additionally, these mixed species plantings provide resources important for breeding birds including potential nest sites and arthropods for nestling sustenance (Simpson, 1949; MacArthur and MacArthur, 1961; Wiens, 1974; Rotenberry, 1985; McCoy et al., 2001). Biofuel production also requires annual or semi-annual harvests, with a main cutting traditionally during fall or winter months to

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* Corresponding author.
E-mail addresses: tjconkling@gmail.com, tconkling@usgs.gov (T.J. Conkling), j.belant@msstate.edu (J.L. Belant), Travis.L.DeVault@aphis.usda.gov (T.L. DeVault), martinj@warnell.uga.edu (J.A. Martin).

[1] Present address: U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Snake River Field Station, Boise, ID 83706, USA.

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maximize total biomass, and a potential secondary cutting for forage or biomass during the summer (Vogel et al., 2002; Fike et al., 2006; Liu et al., 2015). As such, the timing of these additional harvest events can be detrimental to avian species if they occur during the breeding season (Roth et al., 2005) because they destroy active nests, remove vegetative cover, and reduce food availability (Bollinger et al., 1990; Kershner and Bollinger, 1996; Warren and Anderson, 2005; Perlut et al., 2006). Biomass harvests can also reduce plant height and density in subsequent years (Roth et al., 2005) which may leave nests more vulnerable to detection by predators (Martin, 1993). Additionally, most avian species abandon harvested plots for the remainder of the breeding season (Frawley and Best, 1991), limiting future nest attempts and seasonal productivity.

Habitat manipulations can afford unique opportunities to understand management concurrently with ecological concepts. Animals select breeding habitats by distributing themselves across landscapes to maximize fitness within the constraint of resource availability and predation risk to themselves and offspring (Grinnell, 1917; Hildén, 1965; Jones, 2001; Fontaine and Martin, 2006). Considering animal settlement patterns, the ideal free distribution [IFD] model (Fretwell and Lucas, 1969) predicts that local habitat quality determine species' density, resulting in equal fitness across all individuals regardless of habitat quality. In contrast, the ideal despotic distribution [IDD] model (Fretwell, 1972) suggests breeding birds occupy territories based on competition in addition to resource availability, thereby relegating subordinates into lower quality, less productive habitat, which leads to variation in per capita productivity. Regardless of distribution models used to examine individual fitness, resource rich environments and mixed species plantings support greater densities of breeding birds and greater total production of offspring per unit area (Fretwell and Lucas, 1969; Bakker and Higgins, 2009), thereby contributing more individuals to the overall population. Thus, areas receiving multiple annual harvests or containing switchgrass monocultures would be expected to provide lower quality habitat and concomitant avian productivity than areas receiving single annual harvests or containing native warm-season grass mixtures. This effect would be exacerbated if competitive behaviors resulted in unequal per capita productivity across treatments.

We examined the effects of biofuel treatments on nest success, nest density, and productivity of dickcissels (*Spiza americana*), a polygynous, ground and shrub-nesting grassland bird of conservation concern (Blankspoor, 1970; Temple, 2002). We predicted daily survival rate (DSR) and nest density would be greater in native warm-season grasslands (hereafter "NWSG") than in switchgrass monocultures after accounting for other nest survival covariates including microhabitat and plot-level characteristics, ordinal date, and nest age (Jensen and Finck, 2004; Shaffer, 2004; Grant et al., 2005). We also expected nest survival and nest density in multiple-harvested plots to be lower than single-harvested plots due to increased predation risk or direct failures from mowing and plot abandonment following harvest (Frawley and Best, 1991). As productivity per unit area is a product of reproductive success and nest density, even if nest survival was similar across treatment types, we expected plots with greater nest density to produce more offspring per hectare. However, in accordance with ideal free distribution, individual productivity would be similar across all territories, regardless of treatment. Conversely, if males display an ideal despotic distribution (Zimmerman, 1982), males in higher quality territories will also have greater individual productivity. This could have population-level implications for grassland birds if the potential loss of high quality breeding habitat due to biofuel cultivation reduces overall offspring production while also limiting the reproductive efforts of dominant individuals that would normally breed there (Haché et al., 2013).

2. Methods

2.1. Study area

This study was conducted from late April to late July 2011–2013 at B. Bryan Farm in Clay Co., Mississippi, on 16 plots (range: 4.73–8.51 ha) configured in a randomized complete block design. B. Bryan Farm is comprised mostly of row crop agriculture, pastureland, and conservation easements situated within the historical range of the Blackland Prairie (Barone, 2005). Eight plots were planted in spring 2010 with a mixture of warm season grasses (e.g. big bluestem [*Andropogon gerardii*], little bluestem [*Schizachyrium scoparium*], indian grass [*Sorghastrum nutans*]) and forb species including Illinois bundleflower (*Desmanthus illinoensis*), wild blue lupine (*Lupinus perennis*), and tickseed sunflower (*Bidens aristosa*) and eight were planted with switchgrass; other species in the seedbank included giant ragweed (*Ambrosia trifida*), broadleaf signalgrass (*Urochloa platyphylla*) and *Sesbania* spp. All plots were mowed in April 2012 prior to green-up to simulate harvest. Additionally, 4 "multiple harvest" plots of each vegetation type were also harvested annually in late-June 2012 and 2013, resulting in 4 unique treatments: native warm-season grass single harvest ("NWSG single harvest"), switchgrass single harvest ("switchgrass single harvest"), native warm-season grass multiple annual harvest ("NWSG multiple harvest"), and switchgrass multiple annual harvest ("switchgrass multiple harvest"). One switchgrass single harvest plot and 1 switchgrass multiple harvest plot failed to establish sufficient vegetation so we limited subsequent analyses to the remaining 14 plots.

2.2. Territory mapping and banding

We conducted weekly visits to all plots and noted arrival dates of male dickcissels to determine the pattern of habitat settlement from 1 May in 2011 and 24 April in 2012 and 2013 to 15 July each year. Once male dickcissels established territories, we used target mist-netting for territorial males by attracting birds with conspecific playback of songs and call notes. After capture, we aged and banded all adult birds with a USFWS aluminum band and unique 3-color band combination for individual identification under approved permits (Mississippi State University IACUC approval #11-020, Mississippi Cooperative Wildlife Research Unit Federal Bird Banding Permit #22456).

We delineated territory areas for all males in the study plots by conducting surveys every 3–10 days from 0530 to 1200 CDT by walking each plot along 100-m gridlines established to ensure systematic sampling effort and to minimize disturbance to dickcissels (Baker, 2011). If birds were present, we monitored birds from $\geq$15 m for at least 20 min and recorded 3–7 unique bird locations/survey with a handheld Global Positioning System (GPS), excluding locations where birds were influenced by observer presence, (e.g. birds engaged in scolding behaviors directed towards the observer). Following biomass harvest on treatment plots in late-June 2012 and 2013, we continued territory mapping and re-sighting efforts across all plots until 15 July. We used fixed kernel density estimators (KDE) and 95% volume contours to estimate territory size (Silverman, 1986; Worton, 1989) for all territorial males present $\geq$3 weeks for use in subsequent analyses using package *adehabitatHR* (Calenge, 2006) in program R 3.1.3 (R Core Team, 2015). We excluded territories from subsequent density analyses if the calculated 95% KDE contained $\leq$25% of the study plots.