Global Ecology and Conservation 11 (2017) 23–32

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: http://www.elsevier.com/locate/gecco

Original Research Article

Economic and conservation implications of converting exotic forages to native warm-season grass

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A R T I C L E I N F O

Article history:
Received 10 December 2016
Received in revised form 12 April 2017
Accepted 13 April 2017
Available online 6 May 2017

Keywords:
Dickcissel
Land sharing
Livestock
Marginal analysis
Spiza americana
Sustainability

A B S T R A C T

Intensive agriculture can have negative environmental consequences such as nonpoint source pollution and the simplification of biotic communities, and land sharing posits that conservation can be enhanced by integrating agricultural productivity and biodiversity on the same land. In the Southeastern United States, native warm-season grasses (NWSG) may be a land sharing alternative to exotic forages currently in production because of greater livestock gains with lower fertilizer inputs, and habitat for grassland birds. However, uncertainty regarding costs and risk poses an important barrier to incorporating NWSG in livestock operations. We evaluated the economic and conservation implications of NWSG conversion among small, operational-scale pastures (6.8–10.5 ha) during 2011–2012 at the Prairie Research Unit in Monroe Co., Mississippi (USA). We used partial budgets to compare the marginal rate of return (MRR_e) from converting exotic grass pastures to either a NWSG monoculture of Indiangrass (*Sorghastrum nutans*) or a NWSG mix of Indiangrass, little bluestem (*Schizachyrium scoparium*), and big bluestem (*Andropogon gerardii*). We similarly compared changes in productivity of dickcissels (*Spiza americana*), a grassland bird specializing in tall structure. Average daily gain (ADG) of steers and revenue were consistently higher for NWSG treatments than exotic grass pasture, but ADG declined between years. Indiangrass pastures yielded consistently positive MRR_e, indicating producers would receive 16–24% return on investment. Marginal rate of return was lower for mixed NWSG (−12 to 3%), driven by slightly lower livestock ADG and higher establishment costs than for Indiangrass. Sensitivity analyses indicated that MRR_e also was influenced by cattle selling price. Conversely, mixed NWSG increased dickcissel productivity by a greater degree than Indiangrass per amount invested in NWSG conversion, suggesting a tradeoff between livestock and dickcissel production between the two NWSG treatments. Given continued increases in livestock prices, NWSG could be a sustainable land sharing alternative to exotic pastures currently in production, but subsidies and changes in management may be required for NWSG conversion to be viable for producers and to maintain conservation benefits.

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http://dx.doi.org/10.1016/j.gecco.2017.04.006

1. Introduction

Agricultural intensification supplies food to a growing human population by increasing productivity per unit of area through greater inputs of fertilizers, better crop protection, more efficient grazing systems, and other management practices and technologies (Matson et al., 1997; Tilman et al., 2001; Foley et al., 2005). Increases in food production are promoted as part of a conservation strategy known as land sparing, where one maximizes production on agricultural lands to avoid further conversion of natural areas to cultivation (Green et al., 2005; Phalan et al., 2011). However, environmental costs of intensive agriculture may be substantial, including nonpoint source pollution and reductions in the compositional and structural diversity of local vegetation which can negatively impact local biodiversity and production of ecosystem services such as pollination (Losey and Vaughan, 2006; Kleijn et al., 2009). Arguments in favor of land sparing often rely on the premise that reductions in agricultural productivity accompany biodiversity benefits from land sharing (using biodiversity-friendly practices with agriculture; e.g., Green et al., 2005; Phalan et al., 2011), and recent studies support this premise (e.g., Kleijn et al., 2009; Sabatier et al., 2010; Bateman et al., 2013; Mouysset et al., 2015). However, this paradigm may overlook agricultural practices that sustainably increase productivity, provide ecosystem services, and support wildlife (Tscharntke et al., 2012). Furthermore, much of the terrestrial land mass is altered by agriculture and forestry (Hurtt et al., 2006) yet may still be important sources of biodiversity (Pimentel et al., 1992). Developing agricultural practices that meet future increases in food demand without incurring additional environmental costs may be critical to avoiding further biodiversity loss (Matson et al., 1997; Askins et al., 2007; Tscharntke et al., 2012).

In the Southeastern United States, exotic forages such as bermudagrass (*Cynodon dactylon*) and tall fescue *(Schedonorus arundinaceus*) are widely established for beef production (Ball et al., 2007; Barnes et al., 2013), and pastures are often managed with high grazer densities and large inputs of fertilizer (Phillips and Coleman, 1995; Hoveland, 2000). However, high stocking rates and fertilizer use also may increase environmental costs via nonpoint source water and air pollution (Stout et al., 2000; Eickhout et al., 2006; Snyder et al., 2009; Liebig et al., 2010), and exotic grass pastures may negatively impact wildlife (Greenfield et al., 2002; Barnes et al., 2013; Martin et al., 2015; Monroe et al., 2016). Price of nitrogen-based fertilizers also can be highly volatile (Huang et al., 2009) and high fertilizer costs may negate any additional revenue generated by greater forage yield and quality from added nutrient inputs (Phillips and Coleman, 1995; Coleman et al., 2001; Deak et al., 2010).

A sustainable alternative to exotic forages may lie with native warm-season grasses (NWSG; Taylor, 2000; Harper et al., 2007). Varieties of NWSG species can be adapted to local growing conditions, can tolerate drought and poor soil conditions, and do not require heavy nutrient inputs to be productive (Jung et al., 1988; Brejda et al., 1995; Harper et al., 2007; Keyser et al., 2012). Furthermore, native forages may yield competitive livestock gains even when managed with fewer fertilizer inputs than exotic grasses (Phillips and Coleman, 1995; Gillen and Berg, 2001; Lowe et al., 2015; Keyser et al., 2016). Native forages also may offer benefits to wildlife such as grassland birds, whose populations exhibited steep declines during the 20th century (Sauer and Link, 2011). In contrast with the low, sod-forming structure of many exotic forages, native bunchgrasses may be readily used for nesting by certain grassland bird species (Hughes et al., 1999; Giuliano and Daves, 2002; Monroe, 2014).

Incorporating NWSG in cattle production thus has potential to improve sustainability and grassland bird conservation on private lands in the Southeastern U.S. However, NWSG conversion requires substantial costs from establishment and loss of revenue while pastures are taken out of production for 1–2 years. The possibility of not recovering these losses due to establishment failure, variation in market conditions, or weather presents risks for producers and may be a significant barrier to incorporating these grasses in livestock operations (Taylor, 2000; Doll and Jackson, 2009). Data on costs and benefits of NWSG conversion also are needed to inform distribution of cost-share and incentives to producers (Claassen et al., 2008). In northeastern Mississippi, we estimated greater productivity of dickcissels (*Spiza americana*), an obligate grassland bird and neotropical migrant, among pastures recently converted to NWSG compared with exotic forages (Monroe et al., 2016). We also estimated lower dickcissel productivity in grazed than non-grazed NWSG for this tall structure specialist, but grazing may offer producers the opportunity to recover costs from establishment and even increase their net benefits through greater livestock gains with reduced fertilizer costs than with exotic forages. Native warm-season grass pastures may thus be a land sharing alternative to set-aside programs such as the Conservation Reserve Program (CRP). We therefore conducted marginal analyses to evaluate the viability of NWSG using production costs and cattle gains from our study sites. We also conducted sensitivity analyses to evaluate the relative contribution of budget parameters to marginal rate of return. Finally, we used estimates of dickcissel productivity (Monroe et al., 2016) to determine the marginal rate of return for this grassland bird, and consequently the land sharing potential of NWSG pastures.

2. Materials and methods

2.1. Study site and experiment

We assigned 9 pastures (range = 6.8–10.5 ha) to one of three treatments replicated in three blocks at Mississippi State University's Prairie Research Unit (PRU) in Monroe Co., Mississippi, USA (lat 33°47′N, long 88°38′W). The 30-year average (recorded by a weather monitoring station in nearby Aberdeen, Mississippi; NOAA, 2017) for mean monthly precipitation and maximum temperature during the growing season (April–October, 1981–2010) was 104.8 mm and 28.8 °C, respectively.