Biodiversity—The Birds and the Bees and Healthy Grasslands

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Abstract
Losses in biodiversity abound in modern agroecosystems, and biodiversity loss hampers ecosystem function and primary productivity comparable to abiotic stress. One of the most endangered ecosystems in the world is North American tallgrass prairie, and native birds and pollinators that historically depended on tallgrass prairie are in precipitous decline. Fortunately, native warm-season grasses that dominated tallgrass prairie present a valuable opportunity for summer forage to beef producers in the Eastern United States—a time when cool-season grasses endure a lack in productivity called the "summer slump." Tallgrass prairie was sustained by periodic disturbance from grazing and fire, and combining fire and grazing to manage native warm-season grasslands creates greater landscape heterogeneity than grazing of cool-season grasslands alone. As a result, native warm-season grasslands can support a wide variety of native grassland birds and pollinators while providing nutritious summer forage for beef production. Ultimately, establishing native warm-season grasslands on beef producer farms offers synergy between conservation and farm productivity that can translate to farm profitability.

Introduction
Biodiversity is critical to ecosystem function. Losses in biodiversity can reduce primary productivity similarly to abiotic stressors such as excess heat or UV radiation (Hooper et al., 2012). Conversely, increases in biodiversity can increase primary productivity in a variety of ecosystems—including grasslands (Oehri et al., 2017). North America once boasted over 68 million ha of tallgrass prairie that sustained a wide variety of flora and fauna, but over 95% has been converted to agricultural production (Samson & Knopf, 1994). As a result, native tallgrass prairie is one of the most endangered ecosystems in the world, and the species that inhabited tallgrass prairie have been greatly diminished. Grassland birds have declined in particular, with populations decreasing 53.3% since 1970 (Rosenberg et al., 2019). Agricultural intensification, particularly the widespread application of pesticides, has contributed to grassland bird declines through the reduction in food resources such as insects and weed seeds (Boatman et al., 2004). Simultaneously, native pollinator populations have also seen steep declines from mortality and decreased floral resources due to widespread pesticide use (Grixti et al., 2009; Wepprich et al., 2019). In short, grassland bird and pollinator populations are at risk along with the valuable agroecological services they provide: pest control, nutrient cycling, pollination, and ultimately, increased plant productivity (Losey & Vaughan, 2006; Oehri et al., 2017; Whelan et al., 2015). Fortunately, native warm-season grasses (NWSG) that once dominated tallgrass prairie—big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and eastern gamagrass (*Tripsacum dactyloides*)—have proven to be valuable summer forages in the eastern United States when cool-season forages are enduring the "summer slump" (Keyser et al., 2022b). We propose native warm-season grasslands can be utilized in a working lands approach to simultaneously produce beef and provide habitat for grassland birds and pollinators (Keyser et al., 2022a). Herein, we detail the underpinnings of our approach.

Biodiversity in Working Lands
Grassland birds are up to ten times more abundant in grasslands than in croplands, and thirteen times as many nests can be found in grasslands as compared to croplands (Best et al., 1997). Grasslands provide suitable habitat for 13-14 more species of grassland birds than cropland, and croplands support no species of conservation concern (Blank et al., 2014; Patterson & Best, 1996). Pollinators such as native bees and butterflies are also more abundant in grasslands, but pollinator abundance results from floral resources in grasslands rather than grasses alone (Hines & Hendrix, 2005; Myers et al., 2012). For grassland birds in particular, grassland structure is key to creating suitable habitat. Sod-forming grasses are not suitable habitat for bird species such as northern bobwhite (*Colinus virginianus*) due to minimal bare ground and low plant species diversity (Barnes et al., 1995). For these reasons, NWSG provide more suitable habitat for northern bobwhite due to their bunch growth habit (Sinnott et al., 2022). Some grassland bird species such as eastern meadowlark (*Sturnella magna*) and grasshopper sparrows (*Ammodramus savannarum*) can survive in sod-forming grasses (Jacobs et al., 2012; Schmidt et al., 2013), but species such as field sparrows (*Spizella pusilla*), indigo buntings (*Passerina cyanea*), and dickcissels (*Spiza americana*) prefer bunch-growing grasses (Coon et al., 2022; Jacobs et al., 2012; Moorman et al., 2017). Delisle & Savidge (1997) found no difference in avian

abundance between cool-season bunch grasses and NWSG, but generally NWSG demonstrate greater avian abundance than cool-season grasslands (Bakker & Higgins, 2009; Giuliano & Daves, 2002; Schmidt et al., 2013; Walk & Warner, 2000).

Managing Working Lands for Biodiversity

Historically, tallgrass prairies were sustained by two major disturbances—fire and grazing. The interaction of fire and grazing creates a heterogenous landscape, and a variety of habitats are created that historically sustained grassland birds and pollinators (Fuhlendorf et al., 2006). Generally, fire decreases grassland bird abundance and nesting in the growing season following a burn (Powell, 2006; Robel et al., 1998). However, each grassland bird species responds differently to fire. For example, grasshopper sparrow and Smith's longspur (*Calcarius pictus*) peak in abundance the year following a burn at which point abundance decreases, Le Conte's sparrow (*Ammodramus leconteii*) abundance follows an opposite pattern, and eastern meadowlark abundance seems to peak at an intermediate stage following fire (Byers et al., 2017; Hovick et al., 2014). Pollinator abundance is typically greatest in NWSG that undergoes periodic burning (Decker & Harmon-Threatt, 2019; Swengel, 1998; Vogel et al., 2007). Yet, some pollinator species increase in abundance with time since fire while other species decrease with time since fire (Bruninga-Socolar et al., 2022; Vogel et al., 2010). Altogether, rotational burning every 3-5 years is recommended for managing NWSG to sustain all stages of post-fire habitat simultaneously. Grazing has been shown to increase grassland songbird abundance in both warm-season and cool-season pastures (Walk & Warner, 2000). However, species-specific responses are still prevalent. For example, upland sandpiper (*Bartramia longicauda*), eastern meadowlark, and grasshopper sparrow tend to respond positively to grazing while Henslow's sparrows (*Ammodramus henslowii*) tend to respond negatively (Powell, 2006; Wilson et al., 2022). Furthermore, species-specific responses are also prevalent for fire-grazing interactions. Vogel et al. (2007) found butterfly abundance was greatest in NWSG managed with fire and grazing, while Smith et al. (2016) found bee abundance did not differ between NWSG managed with fire and grazing or fire alone. Sinnott et al. (2022) found northern bobwhite survival was greatest when NWSG were both burned and grazed, and Coppedge et al. (2008) found avian diversity was greater in patch-burn grazed pastures than annual burned-and-grazed pastures. Duchardt et al. (2016) obtained a similar result as Coppedge et al. (2008), but high stocking rates increased forage utilization, decreased heterogeneity, and no difference in avian diversity was found between patch-burn grazing and annual burned-and-grazed treatments. Stocking rate also influences nesting success of grassland birds, with high stocking rates resulting in substantial nest losses from trampling (Paine et al., 1996; Temple et al., 1995). Hence, rotational or patch-burn grazing at intermediate stocking rates is also recommended for managing NWSG.

Conclusions

In summary, hosting a diverse variety of grassland bird and pollinator species requires creating a diverse variety of habitats. Grasslands support greater avian and pollinator species diversity than croplands due to greater plant species diversity and greater landscape heterogeneity. Non-native cool-season grasslands provide suitable habitat for some species of grassland birds and pollinators, but the ability of NWSG to be managed with both fire and grazing enables greater landscape heterogeneity than grazing cool-season grasslands alone. Furthermore, rotational burning and grazing in NWSG creates greater landscape heterogeneity and promotes greater biodiversity than whole-area burning and continuous grazing. As such, NWSG provide beef producers not only a valuable opportunity for summer forage, but also a valuable opportunity to increase the diversity of the landscape on their farm and support avian and pollinator species of conservation concern. Increasing the diversity of plant, avian, and pollinator species on beef producer farms offers promising synergy between conservation and farm productivity through improved agroecosystem function. Ultimately, improving agroecosystem function can translate to farm profitability.

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