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Seasonal temperature and precipitation effects on cow–calf production in northern mixed-grass prairie☆

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ABSTRACT

Quantifying the effects of seasonal temperature and precipitation on cow–calf production on rangelands is challenging, as few long-term (> 20 yrs) studies have been reported. However, an understanding of how seasonal weather inconsistency affects beef production is needed for beef producers to better manage their herds on native rangelands to minimize enterprise risk with respect to climatic variability. Cow–calf beef production data collected at the USDA-ARS High Plains Grasslands Research Station near Cheyenne, WY, USA from 1975 to 2012 were tested using model averaging for effects of spring (April–June) and summer (July–September) temperature and precipitation, as well as prior winter (October–March) and prior growing season (April–September) precipitation on beef production. Two breeds were used at different times during the study period (Herefords from 1975 to 2001 and a Red Angus × Charolais × Salers cross from 2003 to 2012; there was no grazing in 2002) and examined separately to test for differential effects of seasonal weather by breed. Herefords were more sensitive to seasonal weather patterns than the crossbreds, with Hereford pair total beef production showing the largest effect sizes and Hereford cows showing the highest R^2 value (0.66) among models. Wet springs and wet winters particularly increased Hereford beef production in this northern mixed-grass prairie, whereas beef production from the crossbreds did not show any weather effect patterns. The model structure used maximizes utility of these data to be built into decision support tools to help ranchers optimize stocking rates and minimize enterprise risk in advance of the grazing season.

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1. Introduction

To accommodate food demand for a growing world population, livestock production will need to increase by 200 million tonnes/yr by 2050 (FAO, 2011). Cow–calf production will therefore need to increase both in quantity and efficiency. Several factors are known to influence cow–calf production. These include genetic background

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of cows and calves (Davis et al., 1994; Grings et al., 1996), cow body composition (Houghton et al., 1990), calving season and weaning date (Grings et al., 2005), stocking rate (Gillen and Sims, 2002; Kothmann et al., 1971), winter diet supplementation (Patterson et al., 1999), and parasite control (Stromberg et al., 1997). Other aspects such as pasture plant composition have also been used to examine cow–calf production and suggest optimal stocking rates (Hart et al., 1988). Though these multiple factors have been documented, other important, but understudied, factors such as seasonal weather variability may also influence cow–calf production on rangelands. A better understanding of seasonal weather effects on beef production from rangelands will ideally translate into reduced enterprise risk and more efficient beef production through increased predictive capacity to match management decisions with expected seasonal weather.

The 30 million ha of northern mixed-grass prairie represents the largest area of rangeland in the United States (Holechek et al., 1998). Within the northern mixed-grass prairie of Wyoming, USA, 91% of ranching operations (the primary land use in this ecosystem) are cow–calf producers (Kachergis et al., 2013). As such, elucidating the effects of seasonal temperature and precipitation on cow–calf production would enhance management of these operations. Though prior work has shown that spring (April+May+June) precipitation increases forage production in northern mixed-grass prairie (Derner and Hart, 2007), and that forage production positively influences cow–calf production (Andales et al., 2005), more work is needed to better understand the direct effects of seasonal weather conditions on cow–calf performance.

There are few published, long-term datasets that would make it possible to elucidate seasonal weather effects on cattle (Briske et al., 2011). Of the few long-term cattle production studies that have been reported, only Derner et al. (2008), MacNeil and Vermeire (2012), and Reeves et al. (in press) directly examined effects of seasonal weather patterns on cattle weight gains. Reeves et al. (in press) showed that yearling steers were differentially impacted by seasonal weather patterns at different stocking rates, with steer production at heavy stocking rates being more sensitive to seasonal weather. At heavier stocking rates, cool, wet springs and warm, wet summers were optimal for yearling steer production in a C_3–C_4 northern mixed-grass prairie. Similarly, Derner et al. (2008) reported that spring (April+May+June) precipitation increased yearling steer weight gains in a C_3–C_4 northern mixed-grass prairie. Further, MacNeil and Vermeire (2012) found that longer, cooler growing seasons were beneficial for Hereford calf weight gains in a C_3-dominated northern mixed-grass prairie. Extending our understanding of seasonal weather effects of cow–calf body weight gains will help develop decision support tools that will allow ranchers to become better managers of their rangeland resources in the face of an increasingly variable climate.

Previous modeling efforts have shown both direct and indirect effects of climate change and variability on cattle production (e.g., Andales et al., 2005; Hanson et al., 1993; Mader et al., 2009; Ritten et al., 2010; Torell et al., 2010). None of these models, however, were built using data that directly linked cattle weight gain responses to temperature and precipitation. For instance, Andales et al. (2005), using the Great Plains Framework for Agricultural Resource Management (GPFARM; Shaffer et al., 2000) decision support system, determined that forage production was a good predictor of cow–calf production. However, including direct effects of environmental conditions such as seasonal temperature and precipitation on beef production may increase prediction accuracy of GPFARM (and other models), especially since environmental conditions can directly impact livestock production (Ames, 1980).

Cow–calf production data from 1975 to 2012 collected at the USDA—Agricultural Research Service (ARS) High Plains Grasslands Research Station (HPGRS) near Cheyenne, WY (see site description below) were used here to test three hypotheses. First, as a result of our similar yearling steer study (Reeves et al., in press), we hypothesized that cool, wet springs and warm, wet summers would increase cow–calf production (kg beef produced/ha) through seasonally optimal conditions for increased forage production in this mixed C_3–C_4 grass system (Derner and Hart, 2007; Williams III, 1974). Second, we hypothesized that cow production would be more sensitive than calf production to seasonal temperature and precipitation variation because cows could withstand body weight loss in support of maintaining milk production for calf production in times of poor seasonal weather conditions that limit forage quality and quantity (Chigaru and Topps, 1981). Finally, we hypothesized that breeds would respond differently to seasonal weather variability (both Herefords and crossbred Red Angus × Charolais × Salers were used at different times during study period; see below). We expected that the larger crossbred cows would produce more milk than smaller Herefords (Cartwright, 1979; Melton et al., 1967), which would translate into enhanced moderation of effects attributed to seasonal weather conditions.

2. Materials and methods

2.1. Site description

This experiment was performed on northern mixed-grass prairie at HPGRS, approximately 7 km northwest of Cheyenne, Wyoming (41°11′N, 104°53′W). Mean annual precipitation (132 yr) is 381 mm, peaking in May (mean annual precipitation was 408 mm during study years). Soils are well-drained, coarse, and largely comprised of Albinas, Ascalon and Altvan loams (mixed mesic Aridic Argiustolls), and Cascajo gravelly loam (mixed mesic Aridic Calciorthid; Stevenson et al., 1984). The primary ecological site is Loamy (Site ID is R067AY122WY). Grasses are the primary vegetation at HPGRS. Perennial cool-season (C_3) graminoids include western wheatgrass (*Pascopyrum smithii* [Rydb.] Á. Löve), needle-and-thread (*Hesperostipa comata* [Trin. & Rupr.] Barkworth), prairie junegrass (*Koeleria macrantha* [Ledeb.] J.A. Schultes), and needleleaf sedge (*Carex duriuscula* C.A. Mey). Blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Griffiths) is the primary perennial warm-season (C_4) grass. Scarlet globemallow (*Sphaeralcea*