Alternative Livestock/Dryland Forage Systems in the Texas Panhandle

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ABSTRACT: Mathematical models are used to determine optimum grazing scenarios for dryland producers. Dryland producers are constrained by individual resources and may be unable to adopt regionally optimum strategies. Risk may be reduced for producers even if constraints prevent adoption of optimal strategies.

Key Words: Relative Risk, Ogallala Aquifer, Crop-Livestock Systems, Wheat

Introduction

Agriculture in the Texas Panhandle region relies heavily upon irrigation. By 1980, irrigated acres in the region reached 1,754,560. However, between 1980 and 1997 irrigated acres declined to 1,363,438 acres as the water availability in the Ogalalla aquifer declined and pumping costs increased. A variety of entities compete for Ogallala aquifer water, including municipal, industrial and conservation interests. Irrigated acres in the region are therefore expected to continue to decline in the long-term due to economic or political forces. Decline in irrigated acreage will result in increasing acreage dedicated to dryland production systems. Additional factors may contribute to a focus on dryland systems. Significant acreage in the Panhandle is enrolled in the Conservation Reserve Program (CRP), and many producers are evaluating land use as they anticipate the expiration of CRP enrollments in the next few years. Specifically, producers must choose between retaining dryland forages, or converting CRP acreage to dryland grain, or other forage-livestock options as they consider CRP land alternatives. Decision aids related to optimum forage system management are therefore in demand.

Precipitation in the region is highly variable. In Amarillo the annual average precipitation over the last 60 years is 19.7 inches (NWS, 2009). However, the range in annual precipitation is from less than 9 inches to over 40 inches. There are pronounced year-to-year variations with as much as 15 to 20 inch differences in consecutive years. A seasonal pattern adds to the variability. Over 50% of the annual precipitation is received from May through October. Regional dryland systems therefore face significant production risk and are aided by decision and management tools.

The land ownership structure in the Texas Panhandle was largely established based on the wide availability of Ogallala aquifer irrigation water. Plentiful irrigation encouraged ownership of management units of less than 640 acres, as such acreage provided acceptable economic returns for a typical producer. Often, production and management units are even smaller, with 320 acre or 160 acre units common. Further, center pivot irrigation systems encouraged land ownership structure in multiples of 160 acres. This ownership structure has largely remained in the Texas Panhandle, despite reduction in irrigation.

Reduced or non-existent irrigation for land areas less than 640 acres is challenging for producers. The risk of catastrophic or nonexistent yields is greatly increased without irrigation. In addition, lower average per acre yields associated with dryland systems often produce insufficient income to support producers on historical acreages of less than 640 acres. A logical solution used to address the lowered or insufficient income/acre associated with dryland systems is to simply expand acreage in an attempt to generate the level of income necessary to support the producer. This approach is common throughout agriculture, and offers several advantages related to scale, especially lower per unit costs of fixed assets such as farm equipment. However, only a minority of producers have transitioned to large scale production.. Most producers have not altered their land ownership or management structure significantly, due to age of producer or owner, absentee ownership, capital requirements, managerial ability, risk aversion, or personal preference. In addition, a persistent social ethic encourages the retention of numerous small production units rather than very large operations.

Production alternatives for Panhandle producers that retain the historical ownership structure are therefore sought.

Several researchers have studied the transition of irrigated to dryland acreage in the Texas Panhandle. The implications of water policy were reported by Almas et. al. (2009). The economic impact of irrigation in the region has been explored by Colette et.al. (2008), and by Almas et al. in 2008, while Lust et. al. (2009) assessed the relative production risk associated with several dryland forage-based production systems. Such studies characterize the regional situation and may provide options suitable to the region as a whole.

Several constraints define the production situation for producers in the region. These include acreage, the availability of irrigation, forages or crops present on the land (e.g. wheat, sorghum-sudan, native rangeland, perennial grasses, other), livestock types, equipment and facilities, contribution of owner labor, availability of hourly labor, and capital. In addition, producers experience uncontrollable variation in yield (due to precipitation) and market price. Thousands of production alternatives exist for individual producers in the region based on various combinations of the factors listed. It is possible via mathematical models to determine the optimum situation from among a very large number of alternatives. In addition, more than one optimum scenario may exist. Individual landowners, however, are constrained by their individual situation, and may not be able to take advantage of optimum combinations that are available within the region, but not to them specifically. Models that are applicable to individual producer situations are therefore valuable.

The objectives of this study are to characterize a range of production alternatives for Texas Panhandle producers; to determine optimum alternatives for producers given their individual constraints, and to describe the relative price risk and production risk for selected production alternatives.

Methods

Mathematical models are developed for four production scenarios. All scenarios address grazing systems, or systems that include both grazing and grain production. Description of price and yield risk associated with the scenarios is presented as well. Alternatives are chosen to represent the range of diversity and constraints associated with small dryland acreages in the study region. An additional four scenarios are developed by combining elements of the original four, but results are not presented here. Scenario descriptions and justification are below.

Scenario 1 (WH), includes 320 acres of dryland wheat, stocker cattle grazing from November 1 through February 28, and grain harvest. Wheat is the most prominent dryland crop in the region. Many producers may plant wheat in rotation with sorghum, fallow, or other crops. However, given a limited acreage, it is common that the entire acreage would be planted to a single crop in a given year. Therefore each of the four primary scenarios assumes a single crop or forage. Scenario 2 (SS) includes 320 acres of dryland sorghum-sudan with stocker cattle grazing from July 1 through September 30. Dryland sorghum-sudan is planted as early as May 15 depending upon spring precipitation and soil moisture. It may be planted as late a mid-July in dry years. Scenario 3 (BS) includes 320 acres of Old World Bluestem grass available for stocker cattle grazing from July 1 through September 31. Regional acreage enrolled in the Conservation Reserve Program (CRP) is largely established with bluestem or a grass mixture including bluestem. Bluestem grass is a warm-season perennial with the most rapid growth occurring during the late summer. Expiration of CRP contracts is occurring in the region. In addition, a significant portion of the non-renewable acreage will come from the region. Some producers will return expired CRP acreage to cropping, but many are encouraged to manage the grass for grazing, as projections and risk are comparable or favorable compared to dryland grain production. Scenario 4 (RG) includes 640 acres of native rangeland available for stocker cattle grazing from May 1 though August 31. A larger acreage is assumed for RG, since it has never been farmed or irrigated, and is more likely to occur in larger units. In addition, the larger acreage or NR provides productive potential similar to that of the other scenarios.

Scenarios 5-8 are combinations of scenarios 1-4. Scenario 5 (SG) includes bluestem and native range for summer grazing, Scenario 6 (SWC) includes wheat for winter grazing and sorghum-sudan for summer grazing, Scenario 7 (SCG) includes bluestem and sorghum-sudan for summer grazing, and Scenario 8 (WCG) includes wheat and native range for winter grazing.

Linear mathematical models are developed for each scenario. The objective function for each optimizes the Net Returns to land, owner labor, and management (NR) for the individual producer given the scenario constraints. Returns are generated in each model from the sale of stocker cattle or grain sales, and require estimation of livestock and grain prices along with livestock weights and grain yields. Activities and constraints for WH are shown in Table 1 to illustrate the model structure.

Cattle prices were obtained from the U.S. Department of Agriculture (USDA) Agriculture Marketing Service office in Amarillo, Texas. Monthly weighted average prices are for the period of 1992-2009, for medium and large 1-2 feeder cattle weights ranging from 350-775 lbs. as reported for the Amarillo livestock auction (USDA, 2009). The Amarillo auction is representative of the region and accessible to small producers who may sell relatively small numbers of cattle. In addition, direct cattle trade in the region is based on the auction prices. Prices distributions, variance, coefficients of variation, and correlation coefficients are determined for prices, purchase costs, and sales revenues associated with each weight class. The expected price for each of the respective weight classes are determined for the time periods when cattle are purchased or sold in each scenario. These prices are entered in the model objective function and contribute to the estimated NR for each scenario. Relative price risk is indicated by the coefficient of variation and is determined for each cattle purchase or sale date and weight category.

Cattle purchase weights for each scenario are set at 575 lb based on typical beginning weights for stocker cattle in the region. Expected steer gain per acre while grazing dryland wheat is estimated in 2009 Texas A&M University AgriLife Extension Crop and Livestock Budgets (AgriLife Budgets, 2009). The steer gain estimate from the District 1 AgriLife budget is chosen as representative of the region, as the district includes the Panhandle. Expected steer gains per acre are estimated by Lust, et.al. (2009) for dryland wheat and sorghum-sudan. Expected individual steer gains for dryland wheat and sorghum-sudan are derived from the expected gain per acre, and then used to determine the expected sale weights for cattle in the optimization models. Expected grain yield and price for dryland wheat is estimated from 2009 Agrilife budgets for dryland wheat in District 1.

Expected forage production for native rangeland and bluestem is determined from the work of Lust (2008). Expected forage yields are then transformed to steer gain based on National Research Council (NRC) nutrient requirements and forage nutrient values. Expected steer gains and returns are reconciled with Agrilife Budgets for summer stocker grazing. Labor and equipment costs associated with each scenario are determined from AgriLife budgets for dryland wheat, dryland sorghum-sudan grazing, and summer and winter stocker grazing budgets.

Precipitation records for Amarillo were obtained from the National Weather Service (NWS, 2009). Records are analyzed for 1992-2009 to correspond with the same time period as the cattle prices. Distributions for precipitation along with variation in annual precipitation are determined. Forage yields under dryland conditions are highly correlated with precipitation. Three precipitation categories (High, Normal, Low) are developed for comparison of production scenarios based on precipitation patterns. Low precipitation years are those with precipitation that falls in the lower 25% of the distribution. The High precipitation category includes years in the upper 15% of the distribution, and Normal years fall in the 60% of the distribution around the mean annual precipitation. Precipitation risk and relative risk is determined by the standard deviation and the coefficient of variation for precipitation during the years of interest.

Expected forage production under High, Normal, and Low precipitation is estimated for each scenario based on precipitation variance. Expected cattle weight gain for High and Low years are determined by transforming forage yield into weight gain via

NRC nutrient requirements and forage nutrient values. Total Returns (TR) and NR are then calculated for High and Low years for each scenario.

Results and Discussion

The four scenarios presented assume purchase of steers weighing 575 pounds. Sale weights for steers range from 735 lbs to 775 lbs. Mean prices for steer purchase and sale are presented in Table 2. Steers purchased in November (WH) had a mean price of \$84.82 per cwt., compared to mean prices of \$90.00 and \$91.73 per cwt for 575 lb steers purchased in May and July, respectively. Steers sold on March 1 (WH) received a mean price of \$80.28 per cwt, compared to \$82.67 for 735 lb steers sold in October (BS), and \$84.00 for steers sold in September (RG).

Steer purchase cost and sales revenue are calculated by multiplying applicable steer weights by purchase and sale prices. Standard deviation (σ) of steer purchase cost is 104.39 for WH, 121.75 for SS and BS, and 111.14 for RG. Coefficient of variation (COV) for steer purchase cost is .2141, .2308, .2308, and .2147 for WH, SS, BS, and RG, respectively. The similarity of the COV for steers purchased in different time periods (fall vs spring) appears to indicate that little additional purchase price risk is incurred based on fall versus spring grazing strategies.

Steer sales revenues have σ of 105.11, 133.33, 1121.11, and 1135.85 for WH, SS, BS, and RG, respectively. Coefficients of variation for steer revenue are .1690 (WH), .2112 (SS), .1993 (BS), and .2156 (RG). The COV for WH revenue is 78% of that for RG, indicating a substantially lower relative risk for steer revenue if sold in March after grazing wheat than if sold at the first of September after grazing rangeland. Correlation coefficients between purchase cost and sales revenue are .9399, .9256, .9328, and .9518 for WH, SS, BS and RG respectively. The similarly high correlations further indicate that relative price risk is not highly related to the time periods for the chosen scenarios.

Net revenues for steers (NRV) for WH, SS, BS and RG scenarios are calculated as the difference in sales revenue and purchase cost for steers in each scenario. The calculation does not include other production costs, and therefore only provides information about price risk and seasonal differences in the scenarios. Variation in annual and seasonal precipitation is shown in Figure 2. This variation is reflected in forage yields, transformed to steer gain, and reflected in NRV. A correlation of -.4875 is observed between May-September precipitation and November-March precipitation, suggesting that risk might be reduced by adoption of both winter and summer grazing strategies. Means, σ, and COV for NRV are shown in Table 3 for High, Normal and Low annual precipitation scenarios. Variation in NRV is evident. Winter grazing (WH) is notably less risky during High or Normal production years compared to summer grazing strategies (SS or BS). The COV for WH (.2162) is about half of that for SS (.3791) and BS (.3949) under the High scenario. Winter grazing presents similar risk advantages under Normal conditions, as COV for BS (.5555) and SS (.4854) are about twice that of WH (.2702). The scenario with Low annual precipitation is the most unfavorable for winter grazing in terms of relative risk to NRV. The COV for WH during a Low year is 1.9735, about double that of SS (.9021), and more than triple the COV of .6130 for RG. The relative risk for WH is notably higher during the Low year than in Normal or High scenarios.

Production costs are added to the NRV in order to determine the expected net return to land, labor and management (NR) for each scenario. In addition, seasonal precipitation distributions correspond to grazing times for each scenario. Results in Table 4 therefore reflect the combined price and precipitation risk associated with the period of grazing for each scenario. The lowest risk alternative is for WH, with the combined price and precipitation risk indicated by the COV of .2162. Combined risk for the other alternatives is notably higher, as indicated by COV of .3791, .3949, and .3369 for SS, BS, and RG, respectively.

Conclusions

Declining irrigation in the Texas Panhandle continues to encourage development of dryland production systems. Individual producers are often limited by land ownership patterns and constraints specific to their situation, and thus may benefit from models that estimate optimum alternatives based on individual producer constraints. Dryland producers face market risk as well as significant production risk due to variable precipitation patterns. Combination systems that adopt both winter and summer grazing may reduce overall risk due to the negative correlation between winter and summer seasonal precipitation. Optimization models that can be tailored to individual landowner needs may provide greater opportunity for small landowners to reduce risk.

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Table 1. Model Structure for Individual Producer Optimization

Major Activity Categories	Major Constraint Categories
Purchase Steers	Acres Wheat
Sell Steers	Acres Sorghum-Sudan
Graze Wheat	Acres Bluestem
Harvest Grain	Acres Native Range
Sell Grain	Number of Steers
Graze Sorghum-Sudan	Number of Cows
Graze Bluestem	Maximum Labor
Graze Native Range	Maximum Borrowing Capacity
Use Equipment	Nutrient Requirements (steers)
Hire Labor	Nutrient Requirements (cows)
Borrow Capital	

Table 2. Mean Steer Prices and Weights

	WH	SS	BS	RG
Purchase Price ($/cwt)	84.82	91.73	91.73	90.00
Purchase Weight (lb)	575	575	575	575
Sale Price ($/cwt)	80.28	84.19	82.67	84
Sale Weight ($/cwt)	775	750	735	750.00

WH dryland wheat with grazing

SS Sorghum-sudan grazing

BS Bluestem grass grazing

RG Native rangeland grazing

Table 3. Net Steer Revenue with High, Normal and Low Precipitation

Year Effect		WH	SS	BS	RG
High	Net Revenue ($)	177.56	143.57	117.44	153.64
	σ	38.3916	54.4320	46.3738	51.7540
	COV	0.2162	0.3791	0.3949	0.3369
Normal	Net Revenue ($)	134.42	103.98	80.16	112.55
	σ	36.3169	50.4790	44.5322	45.4646
	COV	0.2702	0.4854	0.5555	0.4040
Low	Net Revenue ($)	19.14	52.19	36.51	64.19
	σ	37.7628	47.0800	43.9025	39.3518
	COV	1.9735	0.9021	1.2024	0.6130

Net Steer Revenue = (Steer sale price x sale weight) - steer purchase cost

WH dryland wheat with grazing

SS Sorghum-sudan grazing

BS Bluestem grass grazing

RG Native rangeland grazing

Table 4. Net Returns Reflecting Market Risk and Precipitation Risk, 1992-2009

	WH	SS	BS	RG
Net Return ($)	177.56	143.57	117.44	153.64
σ	38.3916	54.4320	46.3738	51.7540
COV	0.2162	0.3791	0.3949	0.3369

Net Return to Land, Labor, and Management

WH dryland wheat with grazing

SS Sorghum-sudan grazing

BS Bluestem grass grazing

RG Native rangeland grazing

Figure 1. Monthly Average Prices for Medium and Large 1 and 2 Steers, Amarillo, TX, 1992-2009

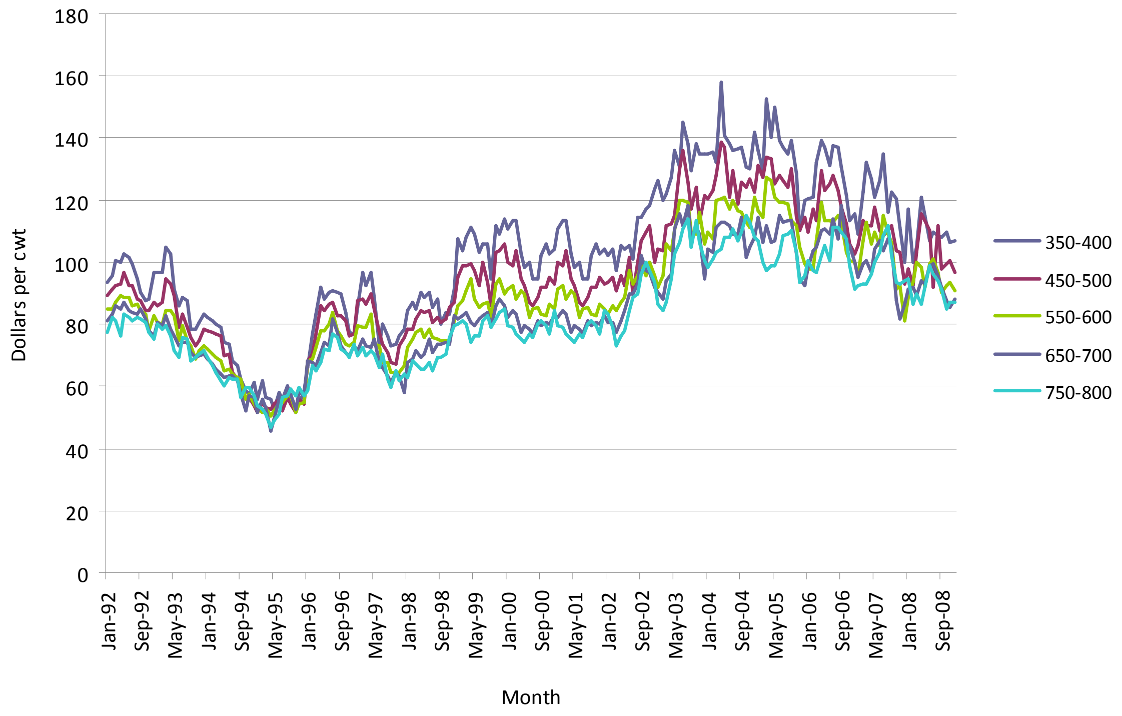
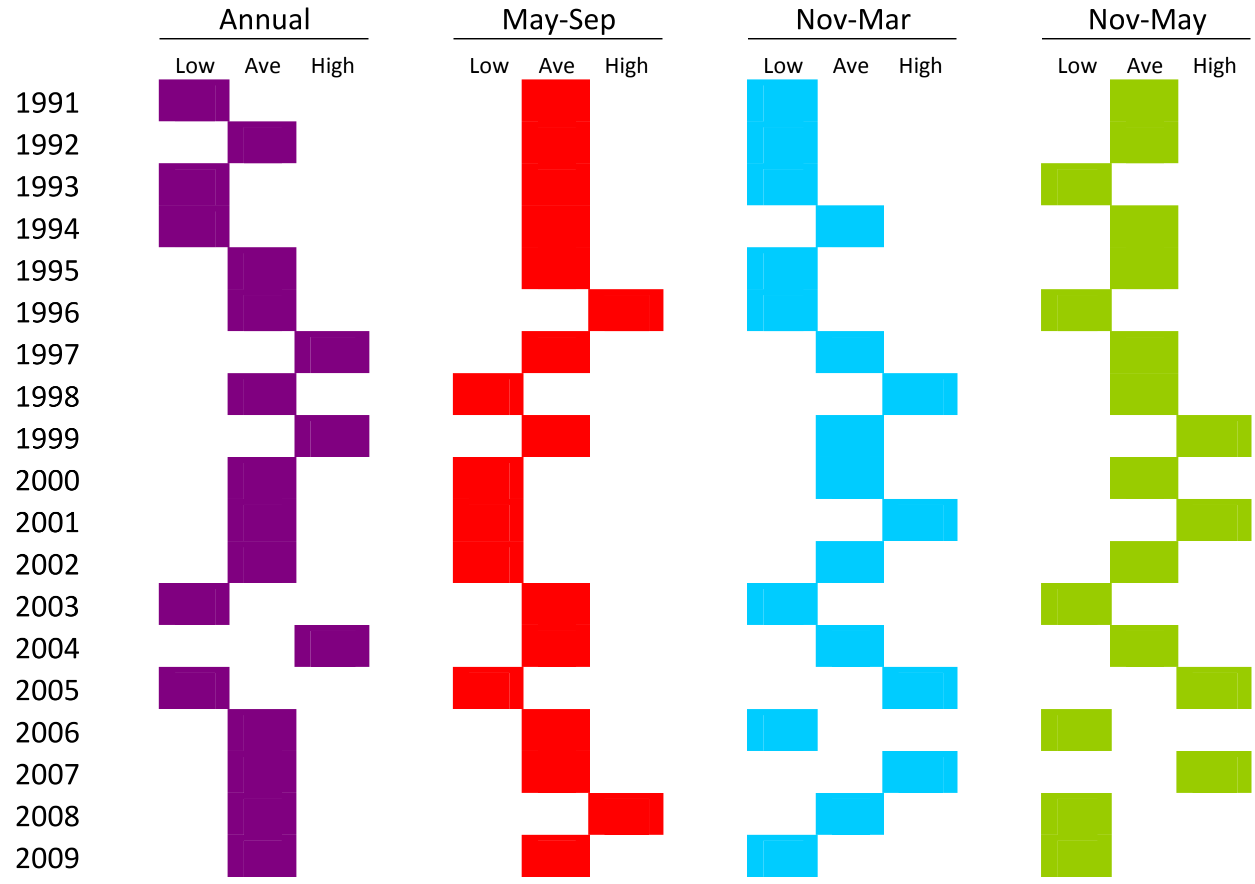


Figure 2. Comparison of Seasonal and Annual Precipitation Patterns, Amarillo, TX, 1991-2009



	Annual			May-Sep			Nov-Mar			Nov-May		
	Low	Ave	High	Low	Ave	High	Low	Ave	High	Low	Ave	High
1991	🟪				🟥		🟦				🟩	
1992		🟪			🟥		🟦				🟩	
1993	🟪				🟥		🟦			🟩		
1994	🟪				🟥			🟦			🟩	
1995		🟪			🟥		🟦				🟩	
1996		🟪				🟥	🟦			🟩		
1997			🟪		🟥			🟦			🟩	
1998		🟪		🟥					🟦		🟩	
1999			🟪		🟥			🟦				🟩
2000		🟪		🟥				🟦			🟩	
2001		🟪		🟥					🟦			🟩
2002		🟪		🟥				🟦			🟩	
2003	🟪				🟥		🟦			🟩		
2004			🟪		🟥			🟦			🟩	
2005	🟪			🟥					🟦			🟩
2006		🟪			🟥		🟦			🟩		
2007		🟪			🟥				🟦			🟩
2008		🟪				🟥		🟦		🟩		
2009		🟪			🟥		🟦			🟩		