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EXAMINING THE CAPACITY OF NEBRASKA RANGELANDS FOR CATTLE PRODUCTION AND EVALUATING DROUGHT MANAGEMENT STRATEGIES

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by

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This thesis has two chapters focusing on the grazing capacity of Nebraska rangelands, and drought management strategies. The first chapter conducts a gap analysis comparing forage supplied by perennial grasslands to the animal unit months (AUMs) required by the cattle. The purpose of this research was to quantify potential AUM supply (i.e., carrying capacity) of grazing lands dominated by perennial grasses on a regional basis in Nebraska to the AUM demand based on cattle inventories and standard production practices in each region of Nebraska. The results suggest that Nebraska is operating at 100% of potential carrying capacity. Harvest efficiency for Nebraska is higher then what is found in this research, due to the overestimation of forage production by using potential grazing acres and potential forage production.

The second chapter of this thesis evaluates drought management strategies for a sample ranch in the Nebraska Sandhills from 2001 to 2017. The drought management strategies evaluated included feeding hay (base case), early weaning the calves at 150 days old and selling them (strategy A), and three strategies which are combined with strategy A: PRF insurance during the growing season (strategy B), PRF insurance spread evenly throughout the year (strategy C) and feeding early weaned calves hay until 210 days old combined with LRP insurance (strategy D). The results of this research are that

strategy C is the least risky and most profitable strategy on average over the 17 years. Even though strategy B is more profitable during drought years, the decision to purchase PRF insurance is required by November 15 of the prior year. You would not know if there is going to be a drought at that time. Results on using LRP insurance were inconclusive, as available LRP data was restricted to seven years total, and only one drought year. More extensive analysis and more data would be needed to decide if LRP should be combined with PRF insurance and/or hay feeding to form a drought management strategy.

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Chapter 1: Examining the Capacity of Nebraska Rangelands for Cattle Production and Evaluating Drought Management Strategies

Introduction

According to the 2017 United States Department of Agriculture National Agriculture Statistics Service report (USDA-NASS 2017), Nebraska is the number one ranked state in the United States for both cattle on feed and for beef slaughtering capacity. It ranks number two in all cattle and calves while ranking number four in the number of beef cows. Beef production has $12.1 billion impact annually to the Nebraska economy including $6.5 billion in direct sales (Nebraska Beef Cattle Facts 2016). The value of beef and veal exports for Nebraska in 2017 was about $1.26 billion (Nebraska Agriculture Fact Card 2017). By way of comparison, the value of field and miscellaneous crops for Nebraska was forecasted to be $9.52 billion in 2017 (USDA-NASS 2018). The value of corn and soybean exports for Nebraska in 2017 was about $2.82 billion (Nebraska Agriculture Fact Card 2017). In 2012, there were 23,280 farms with cattle in Nebraska and 22,977 farms with corn (USDA-NASS 2014).

With over 2.5 million head of cattle on feed and an annual calf crop of approximately 1.65 million head, we used an annual feedlot inventory turnover rate of 1.93 (Jensen and Mark 2010) to estimate that approximately 66% of the feeder cattle that enter into Nebraska feedlots each year are imported into the state. However, this is not the case nationally as the United States beef cow/calf herd population is estimated to be almost five times larger than the population of cattle on feed (Hayek and Garrett 2018).

One questions that comes from this is, can Nebraska expand their cow/calf production? No doubt some of this is due to cow/calf production relying extensively on grass as the primary feed resource. In a recent study on sustainable beef production, Eshel et al. (2018) estimated that current U.S. grazing land can only support 35% of our present daily beef output, without using other feed resources, indicating the need to better understand the productive capacity of various segments of our beef production systems.

Given the above information, our research question is to evaluate the forage production of Nebraska's perennial grazing land systems and their potential to increase cow/calf production in Nebraska. The motivation for this research lies in the fact that there has not been the research conducted necessary to perform and evaluate a gap analysis of the forage supply and demand from perennial grazing lands on a statewide basis.

Previous research has focused primarily on the individual farm or ranch level. Bastian et al. (2009), Ritten et al. (2010a) and Ritten et al. (2010b) explored different range livestock management strategies given extended drought conditions and different price cycles for profitability and risk management purposes. Adams et al. (1994) analyzed extended winter grazing systems for improving economic returns from Nebraska Sandhills cow/calf operations. Others have used forage sampling techniques to estimate carrying capacity in order to compare the impact of different grazing strategies (Grobler 2016) or stocking rates (Holechek and Piper 1992) on grazing land study sites.

There has not been previous research that brings together the forage production potential and the cow-calf demand on a state-wide level in the manner presented here. On the forage production aspect, Epstein et al. (2002) used geographic information system (GIS) mapping of forage potential similar to our methodology to evaluate organic matter decomposition rates in colder versus warmer climates across ten U.S. Great Plains states. Other studies have expanded the scope beyond the farm level but still focused on specific aspects related to stocking rates or forage productivity. Zhang et al. (2007) used remote sensing to compare different methods to evaluate grassland productivity. Mu et al. (2013) used econometric methods to estimate potential changes in stocking rates due to climate change. Mysterud et al. (2014) used mapping districts for landscape-level evaluation of current forage production on alpine ranges of Scandinavia. However, none of these studies compared estimates of forage supply and demand on grazing lands for a region to evaluate the gap between forage supply (carrying capacity) and forage demand (number of AUMs of grazing).

The objectives of this research were (1) to quantify the potential carrying capacity in Nebraska on a regional basis given current perennial grazing land acres and average production conditions and (2) to estimate the current use of this carrying capacity given cattle inventories and standard production practices in each region of the state. Achieving these objectives will provide a baseline for future research in Nebraska to expand cow/calf production in a sustainable way to help meet the supply needs for the Nebraska cattle feeding and processing sectors.

Methods

We started with two simplifying assumptions. The first assumption was that cattle production was the sole user of the perennial grazing resources. The 2012 Census of Agriculture (USDA-NASS 2014) showed 23,152 head of bison in the state of Nebraska primarily in Cherry and Hamilton counties. It also showed 71,771 sheep and 25,840 goats in the state. However, our analysis is focused on the capacity of the current grazing resources to produce calves, so bison, sheep and goats were not included. Our results can be adjusted accordingly under a different assumption that a percentage of those resources are set aside for alternative use. The second simplifying assumption was that current cattle production practices continue in regard to demand for perennial grazing resources. The inclusion of changing production practices such as increased utilization of crop land for grazing or increased dry lot feeding of cows were beyond the scope of this analysis and only addressed in the conclusions by way of discussion about future research needs.

Potential Supply of Perennial Forage for Grazing

Working with the USDA Natural Resource Conservation Service (NRCS), a GIS mapping system was used to estimate the potential perennial forage production in each county based on the most productive plant community best adapted to each ecological site. First, using ArcMap software, all grazing lands classified as grasslands or pasturelands in Nebraska were extracted from the NASS 2012 Cropland Data Layer (CDL). The 2012 CDL was used to match the most recent NASS Census cattle data used in this research to estimate demand for these perennial forage resources. Next, the

National Soil Information System (NASIS) was queried to extract the weighted average production potential (in average years) for each soil map unit in Nebraska. This process is similar to Epstein et al. (2002) but uses the weighted average production potential from NASIS for each map unit, which takes into account the production capacities of all of the major and minor components within it. Each component via this method is assigned a weight, based on its percent makeup of the whole map unit. These tabular data were joined via ArcMap to a geospatial layer of soil map units using a common identifier – the map unit key (MUKEY). Then, using USDA's Soil Data Viewer, an ecological site was generated for each soil map unit. Lastly, these two data layers (soil map units and grassland/pasture) were analyzed against each other via an ArcMap process called zonal statistics. This process calculated the total acres of grassland/pasture available within each individual soil map unit and ecological site. The net result was county level data depicting soil map units, soil map unit acres, potential grazing acres within each map unit, and their weighted average production capacity in pounds per acre during an average precipitation year. Conservation Reserve Program (CRP) land is not included in the grassland/pasture data layer, so it is not included in the estimate of forage available. Grazing land acres and estimated animal unit months (AUMs) of forage supply in each county in Nebraska are shown in the appendix.

We considered three different perennial forage harvest efficiencies: 25%, 30% and 40%. Harvest efficiency refers to the percentage of total forage production that is consumed by the grazing animal; harvest efficiency is affected by the grazing practices the producer is using. A 25% harvest efficiency is typical on grazing lands that are continuously stocked throughout a grazing season. Grazing pressure influences harvest efficiency. A comparison of stocking rates across six North American Great Plains states resulted in average harvest efficiencies of 38%, 24% and 14% (Smart et al. 2010). We used a harvest efficiency of 25% which is commonly associated with a moderate stocking rate as our baseline assumption. The "take half, leave half" rule of thumb is the same as 50% utilization with a 25% harvest efficiency. When using take half, leave half, 50% of the forage is left, 25% is consumed by the grazing livestock, and 25% is trampled, laid on, and consumed by insects or other animals (Redfearn and Bidwell 2017). We also looked at 30% and 40% harvest efficiencies that could result from improved grazing distribution by such practices as fencing and livestock water development, fencing along ecological site boundaries, and increased grazing pressure by such practices as implementation of management-intensive grazing systems. The increased grazing distribution is commonly associated with rotational grazing systems such as a four-pasture deferred rotation (30%) and short duration grazing (35 to 40%). This study assumed an AUM is 780 pounds of air-dry weight forage. Figure 1 shows the AUMs supplied annually by perennial grazing lands in each region under the assumption of 25% harvest efficiency and average growing conditions. Average growing conditions are defined as a year with an average amount of precipitation.

Some assumptions were made for this research that significantly impacted these results. In estimating the pounds of forage available in each region, the most productive plant community was used for each ecological site description. The most productive plant community represents the potential for each ecological site and the potential for each region. Precise estimates of actual aboveground plant production by ecological site (e.g., Natural Resources Inventory, NRCS) were not available at the time of our analysis. Of course, using the production estimate for the most productive plant community instead of the actual production results in a liberal estimate of AUM supply (carrying capacity) for this analysis. This may impact the results significantly; for example, in eastern Nebraska where a majority of pasture acres are predominantly smooth bromegrass and Kentucky bluegrass, the actual plant production is less than the most productive plant community for most eastern Nebraska soil map units. Also, NASS CDL data identified potential perennial grassland/pasture grazing acres in each county, not the acres actually grazed in each county. Some of the acres could be protected sites (e.g., state wildlife management areas) or privately controlled non-grazed acres. Therefore, we have characterized the perennial forage supply for grazing as a *potential* supply under average growing conditions. Pope and Shumway (1984) found that analyzing forage-beef production under average yield grossly overestimates expected returns, so using potential supply would also over estimate production.

Cattle Inventory Demand for Perennial Forage Grazing

We used the 2012 Census of Agriculture (USDA-NASS 2014) to obtain the number of cattle in each county in Nebraska. These numbers included the breakdown for the number of cattle and calves, beef cows, milk cows, cattle on feed, and other cattle.

Numbers for all the classes of cattle needed to complete our analysis were not provided, so we made some assumptions. The first assumption was that replacement heifers were equal to 20% of the beef cow numbers with an equal number of replacement heifer calves and replacement heifer yearlings. Only 80% of the yearling heifers are expected to get bred, and then moved into the cow herd, but all 20% graze. This equates to the assumption of a 16% replacement rate. The second assumption is that the number of bulls were equal to 4% of the beef cow numbers representing a 1 to 25 bull to cow ratio. The number of backgrounding calves (stockers) utilizing grazing resources can then be calculated with the following formula.

(1) Stockers = Other Cattle – Bulls – Cattle on Feed – Replacement Heifer Calves – Replacement Heifer Yearlings

To analyze supply and demand, the state of Nebraska was separated into eight regions to account for different grazing practices throughout the state (Figure 1). Nebraska Extension educators were interviewed to determine the most common practices in each region in regard to the months each year that cattle are on perennial grass pasture. In consultation with the Extension educators, an assumption was made for the whole state in regard to the average size of the different types of cattle during the different times that they are grazing. The weight for the stockers and replacement heifers is the weight that they would be mid-way through the grazing season. Replacement heifers were not separated out into fall and spring herds because replacements for the fall herd commonly come from the spring herd. This information is all summarized in Table 1.

As indicated in Equation 1, data for cattle on feed is necessary to estimate the number of stockers in each county. In some counties, the cattle on feed total was not reported for privacy reasons based on the number of entities reporting. To fill in the missing data, we followed a multi-step process. The first step was to use the midpoint of each farm inventory category less than 500 head for the inventory of the farms in those categories not reporting the number of head (Table 2). For farms in the greater than 500 head category, an attempt was made to find the size of the feedlot by using various sources including Extension educators, the Nebraska Cattle Feeders Directory, articles from area newspapers, and local producers. After these two steps, there remained 18 feedlots with greater than 500 head inventories across the state of Nebraska that were of undetermined size. We determined that there were 180,516 cattle located in these 18 feedlots, or an average of 10,029 per feedlot, by taking the total cattle on feed in Nebraska as reported by NASS and subtracting the total cattle on feed we had already accounted for in the data. In a few counties, applying this average to the feedlots of undetermined size resulted in a negative stocker number. In those counties, the cattle on feed number was reduced to make the stocker number equal to zero with the cattle on feed residual distributed to the other feedlots of undetermined size remaining in the statewide pool. This led to a ‘complete’ dataset for cattle on feed in each county and, thus, completed estimates for stockers on grass in each county in 2012.

The USDA NASS Census provides the total number of cows and heifers calved in each county as well as a breakdown of that total into beef cows and milk (dairy) cows.

Similar to cattle on feed, some milk cow and beef cow totals were not provided for privacy reasons. To fill in the missing data and determine an accurate estimate of the number of beef cows in each county utilizing the grazing resources, another multi-step process was used similar to that used for cattle on feed. The first step was to use the midpoint of each farm inventory category less than 500 head (Table 2) to fill in missing inventory values for beef cows and milk cows. Next, for the counties missing data for operations 500 head or more, the total number of head from farm sizes less than 500 was subtracted from the county total of cows and heifers calved to determine the missing number of cows in the county. The missing number of cows in the county was then divided by the number of operations with 500 or more that were not provided to find the average size of the 500 head or more operations in that county. That number was then used to fill in the missing data for the number of beef cows and milk cows in those counties. After estimating the beef cow and milk cow numbers for each county, a check sum was completed to compare these numbers to the state totals and the result was an overestimation of 1,218 milk cows using county numbers. A uniform percentage adjustment was then applied to the counties that had estimated beef or milk cow data to shift this quantity of the milk cow inventory over to the beef cow inventory and reconcile all of the numbers. Estimated beef cow numbers for each county are shown in appendix A.

Using these practices and the cattle inventory numbers, demand for grazing perennial grass resources was calculated for each county in AUMs and then consolidated into demand totals for each of the eight regions as shown in Figure 1. A linear adjustment was used when calculating AUMs. When the cattle were not grazing, they were assumed to be fed an alternate feed or they were grazing cornstalks. Some regions have a significant number of cows that have calves in the fall (August-October). Fall calving cows spend fewer months grazing perennial forages because nutrient requirements of a lactating cow in the fall and early winter is greater than what can be harvested from dormant vegetation.

Results

Assuming 25% harvest efficiency and average growing conditions, we calculated a total of 21,762,913 AUMs supplied using 2012 grassland/pasture acres in Nebraska. Using the 2012 Nebraska cattle inventory data and the number of months on pasture (Table 1), we calculated a total of 21,780,502 AUMs demanded from perennial grassland/pasture acres. These results indicate that, as a whole, the state of Nebraska was operating at 100% of carrying capacity. The central, east, southwest, northeast, and south-central regions were above their carrying capacity while the Panhandle, Sandhills, and north central regions were below their carrying capacity (Table 3). Some of these regional differences can be explained by animal movements during the production year. For example, cattle from the southwest, central, and northeast regions commonly are transported into the Panhandle, Sandhills, and north-central regions to graze during the summer but are returned to their home region in the fall/early winter. Although the cattle spend much of the year outside their home region, they are counted as being in their home region for the entire year. These grazing season movements were even more apparent when these data were analyzed at the county level and helped prompt the shift to a regional analysis for the state that coincided with identifying differences in the most common grazing practices. Of course, the latter half of 2012 was also plagued by drought conditions which prompted early movement of the cattle off rangelands into feeding pens or crop residue grazing environments which would have further reduced cattle numbers in counties dominated by perennial grazing lands. Another important consideration of this research is that potential forage availability was used instead of actual. Actual forage production would be less than potential, so harvest efficiency for the state would be higher than we found in this research. The 2012 drought impacted where the cattle were and the cattle numbers but did not impact the forage supply because it was estimated using average precipitation.

Harvest efficiency could be sustained at levels higher than 25% if producers adopted management strategies that improve grazing distribution; thereby, increasing carrying capacity. We analyzed carrying capacity using 30% harvest efficiency and 40% harvest efficiency (Table 3). We found only the central, east, and northeast regions to be over capacity under a 30% harvest efficiency assumption. At 40% harvest efficiency, all regions are operating under capacity. In the far-right column of Table 3, we calculated the harvest efficiency for each region and the state under the assumption of 100% capacity. These numbers ranged from 20% in the north-central region to 37% in the east with a statewide harvest efficiency of 25%. These numbers support a conclusion that the perennial grassland/pastureland acres in the state of Nebraska are fully stocked at a harvest efficiency of 25% but not over stocked. This is consistent with the economic theory that resources are put to their best and full economic use under natural market conditions.

Our results indicate Nebraska is operating at full capacity for cow/calf production utilizing perennial grazing land resources if all grazing land were managed extensively (i.e., continuously stocked). Our estimate of the total AUMs demanded by the 2012 Nebraska cattle inventory matched the AUMs supplied under the assumption of 25% harvest efficiency. The Nebraska Farm Real Estate Market Highlights 2017-2018 (Jansen and Stokes 2018) provides average monthly cow/calf pasture rental rates by region. Adjusting these cow/calf pasture rental rates to an AUM rate and matching regions with our analysis, we estimate the AUMs demanded by the 2012 Nebraska cattle inventory to have an economic value of $875 million dollars in 2017. Perennial grazing lands and the cow/calf industry obviously play an important economic role in Nebraska's economy. Any future adjustments to grazing management practices that increase harvest efficiency could have a significant impact on the industry. Nebraska grazing land managers appear to have the potential to increase carrying capacity of perennial forage resources if more management intensive practices (e.g., short duration grazing) that increase harvest efficiency are more commonly implemented across the state.

Summary and Conclusions

This research provides the first statewide carrying capacity gap analysis for Nebraska that has appeared in the literature. The research lays a foundation for many research projects currently in progress (Cox-O'Neill et al., 2017; Drewnoski et al., 2018; Gardine et al., 2018; Warner et al., 2015) or under consideration that are studying the future potential for cattle production in Nebraska. For example, our results indicate that Nebraska cow/calf production is operating at full capacity based on extensive production practices (25% harvest efficiency) including the number of months the animals are grazing perennial pastures and the classification of cattle doing the grazing. Current University of Nebraska studies (Gardine et al., 2018; Warner et al., 2015) are analyzing production systems where cows may spend more time grazing crop residue or more cows are fed in a dry lot setting instead of grazing. These systems could reduce the demand for perennial grazing resources while maintaining an equivalent cow/calf productive capacity or, more likely, increase the demand on perennial grazing resources as the cow herd increases in size because of the increased use of crop residue and annual forages.

The increased interest in the utilization of crop land for growing annual forages as a grazing crop for livestock is driven by a number of factors including the high cost of grazing land, the interest in increasing returns on cropland and the general view that current perennial forage resources are being fully utilized. Our results suggest that, on a statewide basis, perennial forage resources are fully utilized unless harvest efficiency is increased by more widespread use of grazing management strategies that increase harvest efficiency. A move from 25% harvest efficiency to 30% harvest efficiency on a statewide basis represents a potential 20% increase in carrying capacity. Matched with an equivalent increase in cattle demand for that capacity, this could mean a $175 million direct impact on the state in annual use of perennial grasslands.

There is still a lot to be learned from these results. The next stages of this research will include focus group meetings in each region to examine the potential to increase cow/calf production and profit potential. Assessments will be made of grazing strategies as means to increase harvest efficiency on perennial grassland pastures and of changes to current production practices to better utilize cropland acres in conjunction with perennial grassland acres to increase overall carrying capacity. The production potential and production practices vary across the state and imply different feed availability and production risks by region. Future research will examine the susceptibility of each of the eight regions to drought, the different mitigation strategies that could be employed given available resources, and the impact marketing plans could have on the effectiveness of various strategies. Cow/calf production and perennial grassland pastures play a major role in Nebraska's economy. The potential to increase this role is dependent upon efficient and effective use of available resources. The results in the present paper provide an important foundation for this future analysis.

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Appendix A

Estimated Nebraska County-Level Data for Cattle and Perennial Grazing Land (2012)

	Estimated Grazing Demand (AUM's)	Estimated Grazing Supply (AUM's)	Harvest Efficiency (%)	Acres of Grass (Acres)	Estimated Beef Cows that have Calved (Head)
Central Nebraska					
BOONE	121,771	474,218	25.68%	119,736	16,367
GREELEY	205,398	795,445	25.82%	217,245	22,721
HAMILTON	44,580	135,032	33.01%	30,535	5,992
HOWARD	196,656	679,860	28.93%	170,773	21,754
MERRICK	89,473	359,503	24.89%	73,883	12,026
NANCE	87,157	425,492	20.48%	103,265	11,715
PLATTE	114,788	279,706	41.04%	58,767	15,428
POLK	88,266	192,012	45.97%	39,753	11,864
SHERMAN	209,511	854,145	24.53%	215,371	23,176
VALLEY	225,476	834,073	27.03%	215,051	24,942
YORK	31,999	116,338	27.51%	26,469	4,301
Panhandle					
BANNER	151,808	704,756	21.54%	392,093	13,060
BOX BUTTE	245,784	891,786	27.56%	368,818	18,750
CHEYENNE	145,848	627,858	23.23%	321,904	11,390
DAWES	391,842	1,527,637	25.65%	672,572	27,893
DEUEL	60,732	224,713	27.03%	92,218	4,138
GARDEN	337,715	2,249,790	15.01%	835,979	28,178
KIMBALL	127,021	961,116	13.22%	433,241	9,745
MORRILL	447,091	1,518,154	29.45%	692,041	32,866
SCOTTS BLUFF	177,436	445,329	39.84%	239,939	11,565
SHERIDAN	640,280	3,518,296	18.20%	1,257,572	46,329
SIOUX	440,898	2,438,371	18.08%	1,202,658	31,644
East					
BUTLER	197,341	347,697	56.76%	72,606	12,476

CASS	67,680	205,222	32.98%	46,558	4,096
DOUGLAS	21,587	156,196	13.82%	33,030	1,046
GAGE	227,113	683,267	33.24%	151,166	11,139
JEFFERSON	181,301	524,414	34.57%	120,381	10,762
JOHNSON	118,754	470,155	25.26%	98,871	7,976
LANCASTER	165,060	769,370	21.45%	162,608	10,130
NEMAHA	77,333	175,271	44.12%	37,704	4,618
OTOE	116,988	358,748	32.61%	73,094	8,022
PAWNEE	222,593	598,439	37.20%	125,009	10,546
RICHARDSON	220,570	306,874	71.88%	62,590	9,106
SALINE	164,737	314,357	52.40%	71,203	10,147
SARPY	18,594	123,230	15.09%	25,781	1,145
SAUNDERS	189,184	433,892	43.60%	87,018	9,909
SEWARD	190,446	346,455	54.97%	75,590	9,910
Sandhills					
ARTHUR	271,741	1,384,330	19.63%	87,569	16,446
BLAINE	349,545	1,379,250	25.34%	428,191	20,010
CHERRY	2,397,733	10,766,962	22.27%	3,523,843	135,852
GRANT	284,937	1,381,960	20.62%	459,559	16,239
HOOKER	207,218	1,324,195	15.65%	454,089	12,009
KEITH	311,632	1,215,406	25.64%	431,408	17,382
LINCOLN	1,218,851	3,708,278	32.87%	1,183,410	69,252
LOGAN	250,789	958,126	26.17%	313,516	15,367
MCPHERSON	323,911	1,582,925	20.46%	531,793	18,389
THOMAS	236,567	1,270,651	18.62%	440,703	13,298
Southwest					
CHASE	228,361	724,923	31.50%	278,367	15,565
DUNDY	250,978	976,960	25.69%	369,900	16,106
GOSPER	138,985	488,562	28.45%	134,326	11,150
HARLAN	139,397	567,075	24.58%	134,185	12,063
HAYES	164,903	724,348	22.77%	284,262	15,872
HITCHCOCK	170,199	582,394	29.22%	229,949	13,818
FRONTIER	333,763	1,433,985	23.28%	378,709	25,433
FURNAS	161,759	789,489	20.49%	192,711	14,082

PERKINS	162,569	348,965	46.59%	129,776	11,847
PHELPS	152,178	183,563	82.90%	48,202	8,543
RED WILLOW	221,672	754,012	29.40%	206,098	15,288
South Central					
ADAMS	63,447	206,324	30.75%	49,454	6,901
BUFFALO	372,326	928,106	40.12%	239,252	38,780
CLAY	123,488	272,318	45.35%	63,016	13,630
CUSTER	853,785	4,421,913	19.31%	1,177,691	86,057
DAWSON	373,973	1,063,344	35.17%	282,530	33,959
FILLMORE	45,290	134,159	33.76%	31,244	3,962
FRANKLIN	143,831	713,251	20.17%	178,904	15,794
HALL	102,718	282,652	36.34%	65,171	9,024
KEARNEY	110,555	164,970	67.01%	43,497	7,718
NUCKOLLS	158,016	514,626	30.70%	123,122	15,131
THAYER	89,337	325,803	27.42%	80,904	9,858
WEBSTER	160,632	696,221	23.07%	164,551	16,391
Northeast					
ANTELOPE	209,178	532,344	39.29%	134,652	23,242
BURT	44,622	173,556	25.71%	37,934	4,958
CEDAR	197,037	423,110	46.57%	103,815	21,893
COLFAX	96,939	194,168	49.93%	39,364	10,771
CUMING	109,377	200,658	54.51%	40,331	12,153
DAKOTA	27,949	108,026	25.87%	24,204	3,105
DIXON	92,736	285,094	32.53%	65,229	10,304
DODGE	47,655	145,234	32.81%	29,755	5,295
KNOX	400,527	1,356,853	29.52%	345,584	44,503
MADISON	124,875	304,476	41.01%	63,021	13,875
PIERCE	150,228	369,973	40.61%	78,537	16,692
STANTON	96,795	320,896	30.16%	74,967	10,755
THURSTON	40,072	148,235	27.03%	32,813	4,452
WASHINGTON	48,528	202,221	24.00%	42,805	5,392
WAYNE	64,908	154,408	42.04%	32,687	7,212
North Central					
BOYD	221,087	782,478	28.25%	228,291	21,042
BROWN	283,176	2,122,674	13.34%	646,057	31,464
GARFIELD	191,487	1,143,679	16.74%	315,259	17,337
HOLT	1,006,969	4,177,322	24.11%	1,021,639	87,142

KEYA PAHA	238,725	1,333,036	17.91%	384,061	26,525
LOUP	131,678	1,134,749	11.60%	329,650	13,374
ROCK	353,232	2,146,688	16.45%	540,312	39,248
WHEELER	266,824	954,512	27.95%	259,551	21,289

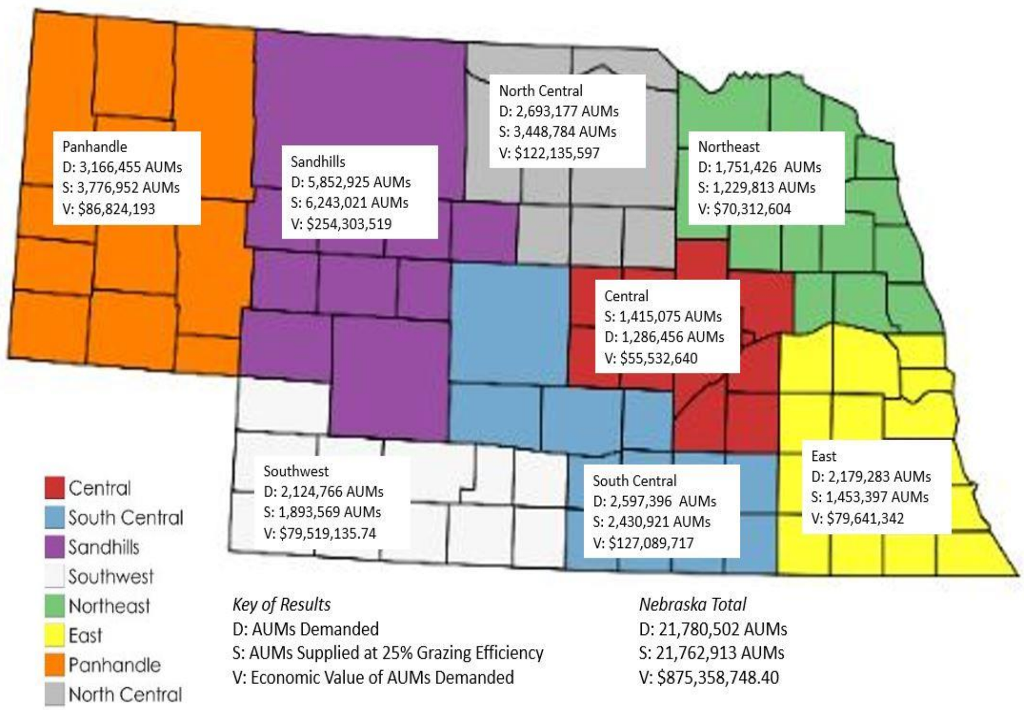

Figure 1: *Regions with AUMs of Forage Supplied and Demanded and Economic Value*

Table 1: *Grazing Practice Assumptions for Each Nebraska Region: Months on Perennial Pasture*

Type of Cattle	Average Weight for the period	Animal Units (AU)	Central Nebraska	East		Southwest		Panhandle	Northeast		South Central	North Central		Sandhills
Calving Season			Spring	Spring (75%)	Fall (25%)	Spring (85%)	Fall (15%)	Spring	Spring (80%)	Fall (20%)	Spring	Spring (90%)	Fall (10%)	Spring
Cow Calf Pairs	**1300 lb cow and 300 lb calf**	1.6	4	7	3	5.5	3.25	5.5	5	0	5	5.5	2	5
Non-Lactating Cows	**1300 lb cow**	1.3	0	2	3	0	2.5	1	0	5	0	0	3.5	4.5
Replacement Heifer Yearlings	**900 lb Heifer**	0.9	4	9		5.75		5.5	5		5	5.5		9.5
Bulls	**2000 lb Bull**	2.0	4	5		5		6.5	5		2	3		9.5
Stocker	**700 lb Calf**	0.7	0	8		5		4	0		2	3		4

Table 2: *Farm Inventory Midpoints*

2012 Farm Inventory	***Midpoint Used***
1 to 9	5*
10 to 19	15*
1 to 19	10**
20 to 49	35
50 to 99	75
100 to 199	150
200 to 499	350

** applies to beef cows and milk cows*

*** applies to cattle on feed*

Table 3: *Results Comparing Nebraska Grazing Demand to Supply*

Region	***25% Harvest Efficiency***	***30% Harvest Efficiency***	***40% Harvest Efficiency***	***Harvest Efficiency assuming 100% Capacity***
Central	110%	92%	69%	28%
East	150%	125%	93%	37%
Southwest	112%	93%	70%	28%
Panhandle	84%	70%	52%	21%
Northeast	142%	119%	89%	36%
South Central	107%	89%	67%	27%
North Central	78%	65%	49%	20%
Sandhills	94%	78%	59%	23%
Nebraska	100%	83%	63%	25%

Chapter 2: Evaluating Drought Management Strategies in the Nebraska Sandhills

Introduction

Beef production plays a large role in Nebraska's economy and drought can have a large impact on the costs of production. Beef production contributes $12.1 billion annually to the Nebraska economy and there are 23 million acres of rangeland, half which is in the Sandhills (Nebraska Beef Council 2018). On a statewide basis, the carrying capacity of grazing lands appears to be fully met by the animal unit days of grazing; therefore, the cattle industry in Nebraska does not have room to expand on perennial grasslands using current production practices (Cumming et al. 2019). This means that during a drought, Nebraska does not have enough grazing land to maintain the current size of the beef cow population. Due to the importance of beef production in Nebraska, it is important for beef producers to have a plan to manage the risk of drought. Grazing lands are one of the most vulnerable parts of Nebraska agriculture to drought risk (Wilhelmi and Wilhite 2002). Drought can bring increased feed costs due to the reduced forage supply from grazing lands, and the decreased market value of cull cows because of the increase in supply of cows going to market.

This research will evaluate the profitability of early weaning verse feeding hay as drought management strategies for a cow-calf producer in the Nebraska Sandhills. This research also will test the effect of Pasture, Rangeland, Forage (PRF) insurance and Livestock Risk Protection (LRP) insurance on early weaning and feeding hay as drought management strategies. PRF insurance is used to mitigate the risk of forage production, and LRP insurance creates a price floor for the calf crop. Given that Nebraska is at full grazing capacity during a year with average precipitation, a drought situation would result in a shortage of grazing land resources for all the cattle grazing in the state (Cumming et al. 2019). Therefore, alternate methods must be used, or the size of beef production must be reduced.

Previous research of this nature has focused on Wyoming and Colorado. Bastian, et al. (2009), Ritten, et al. (2010a) and Ritten, et al. (2010b) explored different range livestock management strategies given multiple severity of droughts and different price cycles for profitability and risk management purposes. They found that late calving was the most profitable. They also found that you should monitor forage condition and then change stocking rates as needed.

Growing season precipitation plays a major role in the amount of forage produced (Stephenson et al. 2018). Stephenson et al (2019) used 17 years of forage data from the Barta Brothers Ranch in the Nebraska Sandhills, and evaluates forage production changes due to drought, and how stocking rates need to change to deal with the reduced forage. The data used in Stephenson et al (2019) will also be used in this research as the forage production for the sample ranch in the Sandhills. A sample ranch was created to overlay the forage production on.

Methodology

Ranch Description

This research is based on a typical ranch in the Nebraska Sandhills. The size and practices of a typical ranch in this area were derived from a focus group survey conducted by Nebraska Extension in August 2018 (McClure 2018). Producers that participated in the survey were located mostly in northern Custer county. The sample ranch has 600 cows and uses a 1 to 25 bull to cow ratio. The assumed weaning rate per cow exposed is 85%. Typical grazing practices are for cow-calf pairs to graze 5 months, and non-lactating cows to graze 4.5 months on perennial grasslands. Replacement heifers and bulls both graze 9.5 months on perennial grasslands. The non-lactating cows, replacement heifers and bulls are fed grass hay for 2.5 months (Cumming et al 2019). The flow of decisions to be made throughout the year and moves of the cattle are shown in figure 2.

Forage Production

Forage production for the sample ranch is derived from forage production data on the University of Nebraska-Lincoln's (UNL) Barta Brothers Ranch, located northwest of Rose, Nebraska (Stephenson et al 2019). Precipitation and forage production data were collected from 2001 to 2017. Drought is classified as below 75% of average precipitation during the growing season, which is defined as April 1 to August 15. During the time frame 2001 to 2017, there were four years that are considered drought years, 2001, 2002, 2006 and 2012.

The amount of hay needed is calculated based on the percent of body weight that the different classes of cattle consume. A lactating cow consumes 2.3% of her body weight per day, and all the other cattle, non-lactating cows, replacement heifers and bulls, in this research consume 2.1% of their body weight (Rasby 2013). The ranch feeds the hay in a hay trailer bale feeder. Of the hay that is fed in a trailer bale feeder, 11.4% is wasted (Tonn 2013). The expected hay waste is accounted for in the calculation of hay feeding quantities for the ranch.

During the time span of 2001 through 2017, an average of 758 acres was needed to produce 110% of the hay that is fed during the 2.5 months that the ranch feeds hay every year, which includes the 11.4% hay waste from the hay trailer. An assumption was made that the ranch will produce 110% of what they expect to feed so that they have some hay on reserve in case there is a drought. At the beginning of the analysis, it was assumed that the ranch had an average of the extra hay produced from 2001 through 2017 to carry over from 2000 into the first year of analysis (2001), since actual forage production data for 2000 was not available. If extra grass hay is needed beyond what the ranch has available, it is purchased. Hay yield was determined by using the Brown county average hay yield in tons per acre to match the ranch location (USDA-NASS). The yield varied each year based on the NASS reports. The forage and hay requirements of the 600 head cow herd, average 18,317 acres of grassland over the 17 years. It is assumed this is the number of acres of perennial grassland on the ranch with 758 used for hay and 17,559 used for grazing.

If the ranch does not use all the hay that it has produced in a given year, the hay is saved in a stock pile to use when it is needed. The oldest hay is fed first, so the stock pile of hay rotates, and the hay is never more than two years old to decrease the nutrient decay of the hay. If hay is carried over for a year in the stock pile, then there is an opportunity cost charged on the value of the hay carried over of 5.5% which is the assumed interest rate charged on the ranch operating note by a bank. The carried over hay also has an assumed loss of 25% due to dry matter loss and loss in digestibility (Henning and Wheaton 1993).

The price of hay is determined from USDA-AMS data for good quality grass hay in large round bales, using an average of the high and low prices for the months correlated with when the hay would be purchased during that year, adjusted for the time value of money, shown in Table 4 (USDA-AMS). The prices used were averaged for the entire state of Nebraska. In 2002, 2007 and 2008 data were not available for good quality grass hay in large round bales, so prices for premium quality grass hay in large round bales were used.

The average inflation rate between 2001 and 2017 of 2.1% was used to adjust hay and feeder cattle prices for the time value of money so that all the cattle and hay prices are in terms of the value of a dollar in 2017 (Consumer Price Index 2018).

Feeding Hay and Early Weaning

The base strategy used in this research is feeding hay. When there is a drought, for the feeding hay strategy, you feed the cow-calf pairs hay, and wean the calves at the normal 210 days of age. The calves are then sold. The alternate strategy, strategy A, is to early wean the calves when there is a drought. In the early weaning strategy, the calves are weaned at 150 days of age and sold. For every 2.5 days that a calf is weaned from the cow, there is one more day of grazing available for the cow (Rasby 2019). After the calves are weaned, the cows continue grazing until they run out of grass, and then they are fed hay. Haigh et al. (2019) evaluated different drought management strategies, to find the relationship between drought preparedness, response and impacts. Feeding hay and early weaning were both included in this research as common drought management strategies.

Cattle Description

The sample ranch calves in March. The calves nurse from the cows until they are weaned. Steer calves that are weaned at 210 days are expected to have an average weight of 525 pounds, and the heifers have an average weight of 475 pounds. The early weaned calves are weaned at 150 days, and steers are expected to weigh 425 pounds and heifers 375 pounds. The early weaned calves are then sold at these weights. Feeder cattle prices are shown in Table 5. The feeder cattle prices used were broken down into 100-pound categories for medium and large framed #1 muscle score (Livestock Marketing Information Center (LMIC) 2019).

An average of the October and November prices for each year were taken and used as the price for the normal weaned calves. For the early weaned calves, an average of the July and August prices for each year was taken and used. The prices are inflation adjusted to 2017 dollars.

Pasture, Rangeland, Forage (PRF) Insurance

PRF insurance is offered by the USDA Risk Management Agency (RMA). The purpose of PRF insurance is to help producers mitigate the risk of forage loss due to a drought. It uses a rainfall index as a proxy for production losses, not actual forage production (Pasture, Rangeland, Forage Pilot Insurance Program 2017). Coverage levels can be chosen from 70 to 90% of expected precipitation, and production levels can be between 60 to 150%. The expected precipitation is based on the precipitation index, and the precipitation that falls in the grid that your land is in. The production level is chosen by the producer and is an adjustment to the county average productive value per acre that determines the dollar value per acre the producer wishes to attach to their coverage. The government subsidizes the insurance between 51 and 59% depending on the coverage level that is chosen (Berger 2017b). A minimum of two, non-overlapping, two-month periods, or index intervals must be selected for coverage. The minimum percent coverage for any one interval is 10%, and the maximum is 60% (Vandeveer and Berger 2013).

In this research, two different PRF insurance policy strategies were evaluated. Since the growing season is from April 1 to August 15, the index intervals April-May, and June-July with 60% and 40% coverage value, respectively, were selected to cover a major portion of the growing season. This will be referred to as strategy B. The other strategy was to cover the entire year by insuring 16.67% of coverage value in January-

February, March-April, May-June, July-August, September-October and November-December, respectively. This will be referred to as strategy C. Data for PRF insurance prices and payouts was retrieved from USDA-RMA (2019). In both strategy B and strategy C, 758 acres were insured as hay land and 17,559 acres were insured for grazing.

Livestock Risk Protection (LRP) Insurance

LRP insurance is used to protect price risk for the future sale of an owner's livestock. Producers are paid if a national price index falls below the insured coverage price on the ending date of the insurance policy. Similar to a put option, an LRP insurance policy sets a price floor and protects the owner from falling prices but leaves the top price open to take advantage of price increases. A few advantages of using LRP insurance instead of a purchasing a put option from the futures market is the flexibility on the number and weight of the cattle that you are insuring. One feeder cattle put option is for 40,000 pounds of 700 to 849 pound medium frame steers. With LRP, there are two different weight groups (less than 600 pounds and 600 to 900 pounds), different prices for steers and heifers, and you can insure a specific number of cattle. There is a 13% subsidy from the USDA on premium costs (Berger 2013).

Producers may insure up to 2,000 cattle with LRP during an insurance year which spans from July 1 to June 30. The producer must retain ownership of the cattle until at least 30 days before the end date of the insurance coverage. The cattle may be sold earlier, but the coverage is either transferred to the new owner or lost (Brooks and Parsons 2014).

The LRP policies evaluated were 13-week contracts for steers and heifers of weight 1 (less than 600 pounds). The policies start on July 15 of each year, or the closest date to that available. Because the cattle must be owned until at least 30 days before the end date of insurance coverage, during a drought, the calves are early weaned at 150 days and fed hay until the age of 210 days old. Doing this prevents the LRP coverage from having to be forfeited.

Partial Budget

Partial budgets were used to compare what would happen over the 17-year time frame if a producer changed from a base case strategy of feeding hay during a drought to one of four other strategies. The revenues and expenses used in the partial budgets are shown in Table 6. The four partial budgets created compared the base case to each of following:

- Strategy A: early weaning the calves at 150 days old and selling them.
- Strategy B: early weaning the calves at 150 days old and selling them combined with PRF insurance during the growing season
- Strategy C: early weaning the calves at 150 days old and selling them combined with PRF insurance spread evenly throughout the year
- Strategy D: early weaning the calves at 150 days old and feeding them hay until 210 days old combined with LRP insurance

The difference in the amount of hay purchased was calculated by taking the difference between the hay needed to feed hay in a drought year and the hay needed when a producer early weans during a drought. The fuel cost to move the bales was $3.38 per ton (FarmDoc University of Illinois 2019). Labor costs to move the bales were $1.53 per ton (USDA-NASS 2016). The difference for both fuel and labor was taken between feeding hay and early weaning.

Results

The results from the partial budgets for strategies A through D are shown in Table 7. Strategy A results indicate that early weaning during drought years was more profitable than weaning at the regular time (210 days following calving) and feeding hay to the cow-calf pairs longer. In non-drought years, there is no difference because the calves are not early weaned. In strategy B, during the drought years, it was more profitable to early wean and use the growing season PRF than it was to not use PRF insurance. In non-drought years, profitability varied from -$30,142 to $222,696 when calves were not early weaned and growing season PRF was included. In strategy C, early weaning combined with using PRF split evenly across the year was more profitable than feeding hay to the cow-calf pairs (base case) by an average of $66,012.49. During non-drought years, calves are not early weaned, but returns from strategy C with PRF split evenly across the year compared to the base case ranges from a -$2,749 to a $165,609 difference in profitability. On average, in non-drought years, it was more profitable to include PRF insurance split over the entire year than it is to use PRF during the growing season (strategy B). Overall, during the 17 years of data analyzed, average returns from strategy C exceeded average returns from strategy B by over $17,700.

In analyzing strategy D, LRP data was only available from 2011 through 2017. There is only one drought in that time period. During the drought year of 2012, cattle prices did not fall below the highest LRP coverage price available so there was not an LRP indemnity payment received. The net result of early weaning the calves and feeding them hay to be sold at 210 days old was -$50,894.02. Over the seven years with data, the average net result of strategy D compared to the base case was -$7,046.29. While limited, this analysis indicates a drought management strategy of early weaning the calves and feeding them hay until they reach 210 days of age combined with LRP insurance to protect price would not increase profitability for the ranch.

The coefficient of variation for the partial budget results was used to evaluate the risk of the strategies A-D compared to the base case. Over the 17-year time period, strategy C was the least risky strategy. When only looking at the four drought years, strategy A was less risky than strategies B and C, but it produced a significantly lower average return than the other two strategies. Because there was only one drought year included in strategy D, risk was not able to be evaluated.

During drought years, 3 out of the 4 years, strategy B is the most profitable, and in one year strategy C is the most profitable. Over the 17-year time frame, strategy A is the most profitable one year, strategy B seven years, strategy C seven years, and strategy D two years. When comparing strategy A to B, A had no negative years, and B had 8 negative years compared to the base case of feeding hay. When comparing strategy A and B, B is more profitable 9 out of 17 years, by an average of over $38,900, and B is more profitable in all 4 drought years. The advantage of strategy A is that there is never a negative net difference, but on average it is much less profitable.

When comparing strategy B to C, B has 8 negative years compared to the base case with an average of return difference of -$20,723, C has 3 negative years with an average return difference of -$1,160.42. Strategy C is more profitable in 10 of the 17 years. Over the 17 years, strategy C is more profitable by an average of $17,720. Since you must purchase PRF insurance by November 15, you will not know if the next year will be a drought, on average you will be more profitable implementing strategy C. If you are most concerned about drought year profitability, you would choose strategy B, because it is more profitable than strategy C in 3 of the 4 drought years.

When comparing strategy C to D, over the 7 years that data for LRP was available, C has 3 negative years and D has 5. Strategy D is only more profitable then C in 2 of the 7 years. On average strategy C is more profitable then D by $73,058.

When choosing a strategy, it is important for producers to look at the objectives of their operation and decide what their main concerns are that would restrict them from achieving those objectives. If you are most concerned about the pay out during drought years, you would choose strategy B. If the main concern is what happens on average, you would choose strategy C. Strategy A would be chosen if your main concern was never having a negative net difference from the base case of feeding hay in a drought year.

Summary and Conclusions

This research provides the analysis of drought management strategies for a sample ranch in Nebraska. Strategies analyzed included a base case of feeding hay to the cow-calf pairs and weaning the calves at the normal 210 days of age. Alternative strategies included: (A) early weaning the calves at 150 days old and selling them; (B) early weaning the calves at 150 days old and selling them combined with PRF insurance during the growing season; (C) early weaning the calves at 150 days old and selling them combined with PRF insurance spread evenly throughout the year; and, (D) early weaning the calves at 150 days old and feeding them hay until 210 days old combined with LRP insurance. The decision to purchase PRF insurance must be made by November 15 of the prior year (Berger 2017a), long before you know if the year is going to be a drought. This makes identification of the best strategy important to producers.

This analysis showed that strategy C, early weaning the calves and selling them combined with PRF insurance spread evenly throughout the year, would be your best option. It is the least risky and has the highest average net difference over the base case during the 17 years analyzed. Since only one drought year was available during the years LRP was available, this research is not able to conclude if LRP is a useful drought management strategy. However, our results for the seven years of data available for this analysis, indicated LRP may not be a useful strategy to manage drought risk or increase returns.

Both PRF insurance coverage for the growing season and PRF insurance coverage split evenly over the entire year, as well as LRP insurance are external risk management strategies. They transfer the risk to an outside source from the ranch. Changing from feeding hay to early weaning and having a stock pile of hay are examples of internal risk management strategies. Choosing a strategy that combines the use of both internal and external risk management strategies is better for the ranch so that they do not keep all the risk within the operation. There are many other risk management strategies that could extend the analysis presented in this research including partial liquidation of the cow herd, using a later calving season, or retaining ownership of steers as yearlings that could be sold during a drought if grazing resources are limited. The results of this research provide an important baseline for future comparisons of possible drought risk management strategies for cow-calf ranches in the United States.

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Appendix B

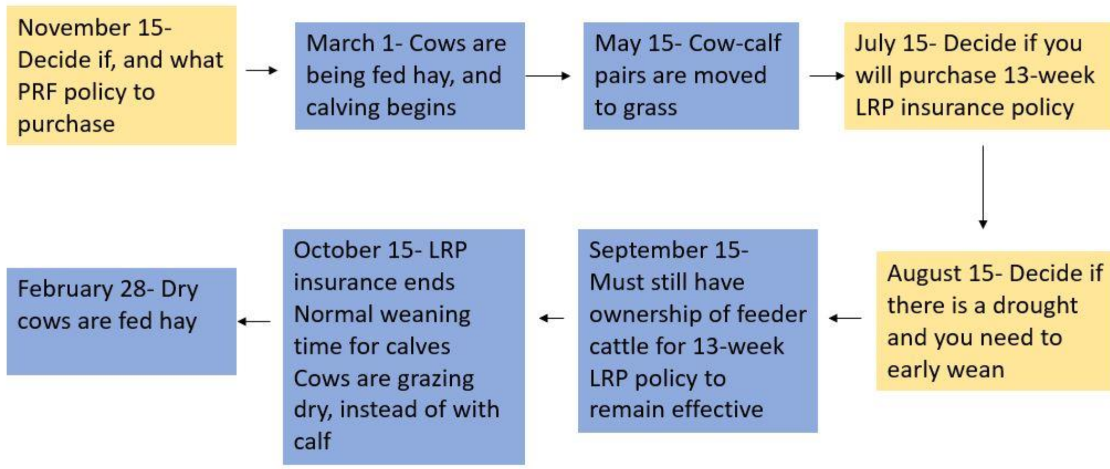

Figure 2: *Timing of Decisions and Operations*

Table 4: *Hay Prices 2001 to 2017 (USDA-AMS)*

Year	Hay price per ton (in 2017 dollars)	Months
2001	$85.27	January 2002-May 2002
2002	$129.75	December 2002- May 2003
2003	$76.92	March 2004-May 2004
2004	$75.34	March 2005-May 2005
2005	$74.32	March 2006-May 2006
2006	$99.74	December 2006- May 2007
2007	$102.58	March 2008-May 2008
2008	$102.48	March 2009-May 2009
2009	$91.52	March 2010- May 2010
2010	$78.07	March 2011- May 2011
2011	$109.79	March 2012- May 2012
2012	$242.01	February 2013- May 2013
2013	$115.64	March 2014-May 2014
2014	$121.48	March 2015-May 2015
2015	$103.11	March 2016-May 2016
2016	$66.58	March 2017-May 2017
2017	$99.17	March 2017-May 2018

Table 5: *Feeder Cattle Prices Adjusted for Time Value of Money* (Livestock Marketing Information Center (LMIC) 2019)*

Year	500-600 lb Feeder Steers October-November Average (CWT)	400-500 lb Feeder Heifers October-November Average (CWT)	400-500 lb Feeder Steers July-August Average (CWT)	300-400 lb. Feeder Heifers July-August Average (CWT)
2001	$135.84	$133.90	$166.17	$167.96
2002	$123.60	$121.82	$136.63	$134.07
2003	$150.73	$150.89	$157.35	$156.14
2004	$165.74	$167.75	$193.77	$192.60
2005	$175.13	$176.84	$182.91	$183.41
2006	$151.56	$152.66	$185.98	$184.27
2007	$150.14	$148.21	$172.40	$175.93
2008	$130.98	$124.94	$156.00	$154.28
2009	$124.14	$120.26	$145.34	$139.21
2010	$146.22	$142.12	$161.28	$150.35
2011	$181.30	$175.80	$186.43	$181.83
2012	$184.39	$176.79	$195.24	$192.84
2013	$210.17	$204.65	$212.51	$202.73
2014	$315.90	$319.61	$338.24	$323.33
2015	$226.92	$225.82	$327.11	$332.99
2016	$144.01	$137.14	$179.61	$175.37
2017	$182.83	$173.37	$187.22	$183.99

*2017 dollars

Table 6: *Partial Budget*

Added Revenue	**Decreased Revenue**
Heifer and steer sales (early weaned if it is a drought year, otherwise fed hay)	Heifer and steer sales (feed hay)
PRF insurance payout strategy B (grazing land and hay)	
PRF insurance payout strategy C (grazing land and hay)	
LRP indemnity payment strategy D (steers and heifers)	
Decreased Costs	**Increased Costs**
Difference in amount of hay purchased	Opportunity cost for stock pile of hay
Difference in amount of fuel needed to feed hay	Difference in amount of hay spoiled
Difference in labor costs to feed hay	PRF insurance cost strategy B (grazing land and hay)
	PRF insurance cost strategy C (grazing land and hay)
	LRP premium cost strategy D (steers and heifers)

Table 7: *Results for Strategies A-D compared to a base case strategy of feeding hay in drought years to cow-calf pairs until normal weaning age of 210 days.*

Year	Strategy A (early weaning calves and selling them)	Strategy B (early weaning calves and selling them + growing season PRF)	Strategy C (early weaning calves and selling them + full year PRF)	Strategy D (early weaning calves and feeding them + LRP)
2001*	$20,905.82	$43,185.74	$29,420.42	N/A
2002*	$40,676.64	$253,647.08	$232,116.97	N/A
2003	$0.00	-$30,142.31	$88,010.69	N/A
2004	$0.00	$222,695.96	$165,609.09	N/A
2005	$0.00	-$28,915.12	$100,156.65	N/A
2006*	$49,007.24	$209,559.85	$154,835.25	N/A
2007	$0.00	$34,728.74	-$2,749.05	N/A
2008	$0.00	-$4,769.78	$59,316.24	N/A
2009	$0.00	-$26,608.60	$21,388.03	N/A
2010	$0.00	-$8,902.60	$15,922.55	N/A
2011	$0.00	$33,219.06	$37,139.66	-$8,261.58
2012*	$48,907.27	$129,253.18	$159,032.39	-$50,894.02
2013	$0.00	-$19,955.07	-$16.47	-$13,919.28
2014	$0.00	$41,661.07	$31,422.25	-$11,829.74
2015	$0.00	-$23,489.16	$18,006.30	$48,324.02
2016	$0.00	-$23,006.04	-$715.74	$24,999.78
2017	$0.00	$18,812.95	$13,317.11	-$37,743.19
All Year Avg	$9,382.18	$48,292.64	$66,012.49	-$7,046.29
Drought Year Avg	$39,874.24	$158,911.46	$143,851.26	-$50,894.02
Minimum	$0.00	-$30,142.31	-$2,749.05	-$50,894.02
Maximum	$49,007.24	$253,647.08	$232,116.97	$48,324.02
Coefficient of Variation	196.86%	194.29%	115.32%	-485.76%
Coefficient of Variation Drought Years	33.19%	58.37%	58.49%	N/A

*Drought Year