# PATCH-BURNING AND GRAZING:

# AN ECONOMIC ANALYSIS OF RANGELAND

# MANAGEMENT OF OKLAHOMA

# COW-CALF PRODUCERS

By

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Abstract: Cattle production involves making complex decisions that influence producer profitability, the environment, and the beef industry. Rangeland management decisions require cattle producers to select practices that improve the sustainability of their rangelands to maintain cattle production while also remaining profitable. The invasion of Eastern red cedar across rangelands due to fire suppression is limiting the number of grazeable acres for cattle, which is the number one use of Oklahoma rangelands. Woody plant encroachment combined with drought impacts becomes expensive for cattle producers who are forced to supplement, destock, or both. The utilization of pyric-herbivory, the interaction between fire and grazing, in the form of patch-burning and grazing is a practice that offers benefits to accomplish the goal of profitable rangeland management. Benefits create improved rangeland productivity by providing high-quality forages, mitigation for drought impacts, and control of woody plant encroachment.

Despite these benefits, adoption of patch-burning and grazing by cattle producers is scarce. The objectives of building an economic analysis of patch-burning and grazing involve raising awareness by providing the costs and long-term economic benefits of implementing patch-burning and grazing and comparing them to the more traditional approach of burning an entire pasture every three years.

Results indicate that patch-burning and grazing will cost approximately $2 more per acre per year than burning the entire pasture every three years. However, the benefit of cows having continual access to high-quality forages in recently burned areas results in a $20/cow/year savings in winter supplementation costs. Patch-burning and grazing also offers mitigation for drought impacts. It is estimated that in a drought year, deciding to skip burning a patch provides an additional five days of grazing for cattle on stockpiled forage in unburned areas. Utilizing patch-burning and grazing before a drought, not burning during a drought year, and resuming after the drought reduces supplementation and burn costs by 2.05 percent and increases the future value of savings by $113/cow compared to traditional management practices after six years. An economic analysis of patch-burning and grazing provides beneficial economic information to aid Oklahoma cow-calf producers in the decision-making process of rangeland management.

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## INTRODUCTION

Cattle production is a process of making complex and intertwined decisions that affect producers' profitability, the environment, and the beef industry. One important decision is the appropriate management of rangelands. Sustainable rangelands are vital for raising cattle. Therefore, cattle producers are responsible for managing the land using efficient and profitable practices. The United States (U.S.) cattle industry is driven by consumer demand for beef. The retail value of beef produced in the U.S. was $123.3 billion in 2020 (ERS 2020). Beef consumption in the U.S. reached a new high of 30 million pounds consumed in 2021 (Shahbandeh 2023; USDA, National Agricultural Statistics Service 2023a). To meet consumer demand for beef while being profitable, producers make complex management decisions to reduce costs and increase revenue while serving as stewards of the land. For example, supplemental feed costs are offset by effectively managing grazeable rangelands. However, without proper soil and forage management on rangelands, the profitability and long-term costs of cattle production are affected.

Drought and woody plant encroachment (WPE) are both hinderances to sustainable rangelands. During drought years, the management of forages becomes even more crucial. Drought results in decreases in forage production, leading to destocking, and ultimately affecting overall net returns and profit. Additionally, limited forages on rangelands can lead to an increase in feed costs and other input costs to supplement for nutrient deficiencies otherwise provided by forages through the soil. WPE is also taking over rangelands and reducing forage production for cattle. This is defined as the relative abundance or dominance of grasses and woody vegetation (Archer et al. 2017). Eastern Red Cedar for example, has become one of leading invasive species affecting the productivity of rangelands in the central Southern Plains.

Some management techniques designed to limit the effects of drought and WPE on forages includes burning (pyric practices) and grazing. Research demonstrates that pyric-herbivory, the fire-grazing interaction, can mitigate the effects of drought on livestock production (Allred et al. 2011). Unfortunately, fire has been, and is still viewed more as a harmful land management practice due to damage caused by wildfires. Since European settlement in the late $19^{th}$ and early 20th centuries, fire suppression has increased (DeSantis, Hallgreen and Stahle 2011). The lack of fire has resulted in increased WPE on rangelands and reduced forage production for cattle. The loss of forage because of WPE, combined with drought impacts becomes a costly issue for cattle producers.

**Oklahoma Rangelands**

Cattle production is the predominant use of rangelands as cattle producers rely heavily on the native forages for cattle to graze (McGranahan et al. 2012). Therefore, rangeland management is vital to the profitability of cattle production. Forage production across the state of Oklahoma varies depending on the region, vegetation, and historical management practices. Rangelands are uncultivated lands on which the native vegetation is predominantly grasses, grass-like plants, forbs, or shrubs suitable for grazing or browsing use. The most common types of rangelands in Oklahoma include Cross timbers, Shortgrass Prairie, Shinnery Oak Grassland, Tallgrass Prairie, and Mesquite Grasslands (USDA, Natural Resources Conservation Service 2018; Web Atlas of Oklahoma 2005) (Figure 1). Various vegetation on these rangelands is due to various soil types across the state (Figure 2). For example, sandy soils are more common in western Oklahoma and are more suitable for Sandsage-Bluestem Prairie, while eastern Oklahoma is a better environment for Cross timbers (McMurphy, Gillen and Engle 1990; Web Atlas of Oklahoma 2005).

Figure 1. Soil Map of Oklahoma (Web Atlas of Oklahoma 2005)

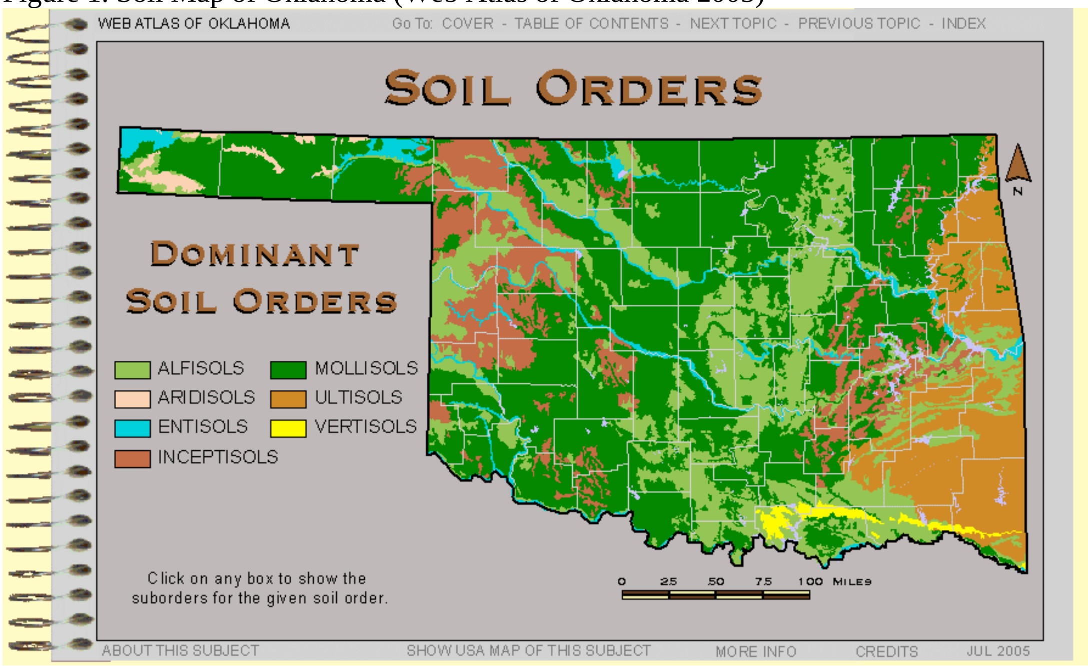
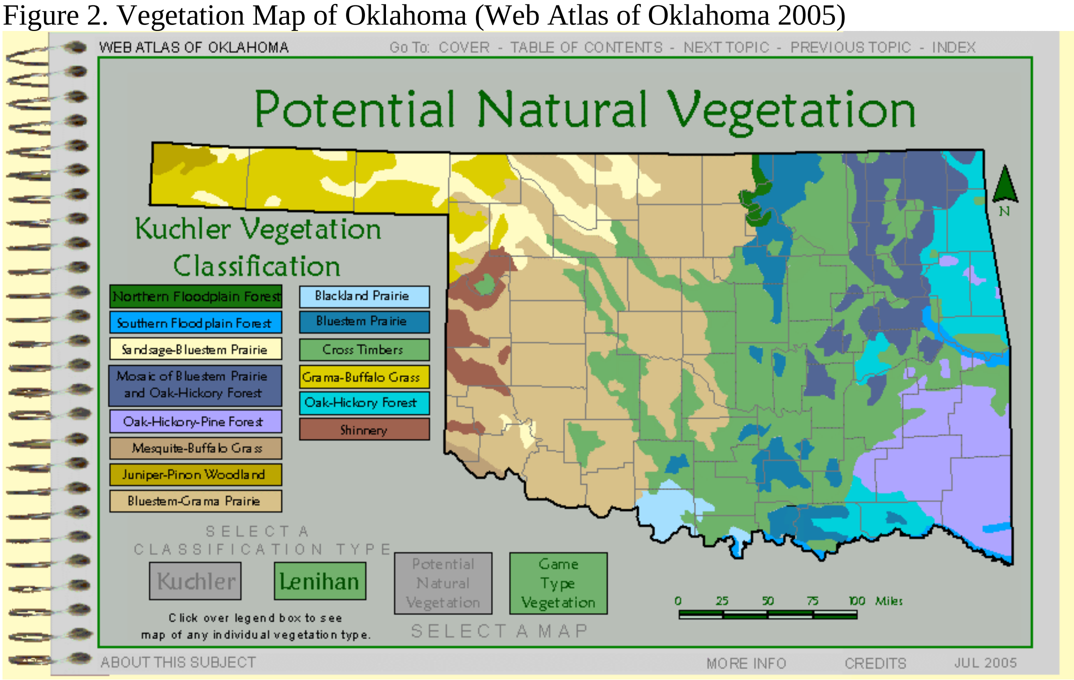



Figure 2. Vegetation Map of Oklahoma (Web Atlas of Oklahoma 2005)



Proper management on rangelands directly impacts cattle and beef production in Oklahoma and the United States. The use of rangelands for cattle grazing is the best way to convert forage, an unconsumable product for humans, to beef - a consumable and demanded product. As of January 2023, approximately 28.9 million head of beef cattle rely on Oklahoma rangelands for sustainable nutrients (USDA, National Agricultural Statistics Service 2023b). Rangelands account for approximately 44.5% of land cover in the U.S., totaling over 400 million acres. In Oklahoma, grazing rangelands account for approximately 19 million acres, 56.4% of land cover across the state, and is the number one use of land (USDA, National Agricultural Statistics Service 2019). The diversity of native vegetation and the management practices used to maintain rangelands are what set them apart from introduced pastures (US EPA 2015). However, the percent utilization of available forage on rangelands in Oklahoma is lower than the percent utilization on introduced pastures (Redfearn and Bidwell 2017). Therefore, proper management techniques, such as optimal stocking rates and prescribed fire, are necessary for continuous sustainability for cattle on Oklahoma rangelands. Limited forage production due to poor planning and management lead to costly alternatives for cattle producers, such as increased supplemental feed requirements to offset nutrient deficiencies or destocking and liquidation of a herd (McGranahan et al. 2012; Weir et al. 2013).

## Oklahoma Production

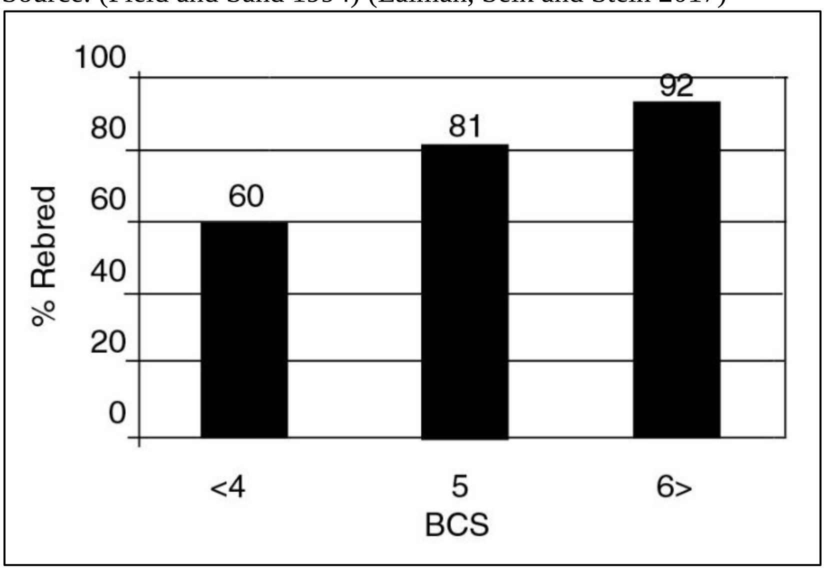
Cattle production in the U.S. involves several segments to produce beef products for consumers. From seedstock producers to the packing plants, the process of producing beef starts with forage. Cows on cow-calf operations rely on forages year-round to maintain body condition and to raise a healthy calf each year. Operations with 100 or more beef cows compose 9.9% of all beef operations and 56% of the beef cow inventory (USDA ERS 2022). Backgrounders or stocker operations, for example, are vital for the growing stages of calves. Approximately 60% of cattle in feedlots go through a stocker operation where they graze pastures for roughly six to seven months (Turcios 2022). Feedlots are concentrated in the Great Plains region as well as the Corn Belt, Southwest, and Pacific Northwest regions. Capacities range from less than 1,000 head to over 32,000 head. Feedlots with more than 1,000 head make up five percent of feedlots but market 80-85% of all fed cattle (USDA ERS 2022). Beef production is not economical without efficient cattle production. Therefore, beef production must start with effective and profitable rangeland management for beef cows to graze.

As of January 2023, Oklahoma ranks second in the nation behind Texas in the number of beef cows with approximately 1.9 million beef cows in inventory, making up a $1.97 billion industry (USDA, National Agricultural Statistics Service 2023b; USDA, National Agricultural Statistics Service 2019). The state ranks second in cow-calf production, with two-thirds of cow-calf herds containing less than 100 head of cows  (Rocateli et al. 2018) (Vestal et al. 2017a). Cattle production activities in Oklahoma also include stocker-only operations and retaining calves as stockers. Results from a survey sent out with the Oklahoma Beef Cattle Manual, starting in 2005, were published in 2017 conveying the production and management practices of Oklahoma cattle producers. The content of the survey included questions regarding demographics, business planning, nutrition and forage management, reproduction and genetics, and marketing. Conclusions show that 91.1 percent of producers are cow-calf producers with 45.3 percent involved in some form of stocker production. The dominant system of cattle production in Oklahoma involves grazing (Shideler et al. 2012). Cattle rely on forages to obtain sustainable nutrients to maintain body condition score (BCS) throughout the year. Weight gains for calves before, during, and after weaning are conditional on pasture conditions and potentially affect net returns for producers.

There are many decisions that go into operating a successful cow-calf operation. Reproduction management, forages, nutrition management, and more must be carefully planned and implemented to manage costs and maximize profits. Fifty-seven percent of cow-calf producers in

Oklahoma have a long-term business plan for their operations and realize the importance of record keeping for both finances and production records (Vestal et al. 2017a). Oklahoma producers must make decisions on how to best raise and market calves while maintaining a healthy BCS of cows. Monitoring the BCS of a cow herd, especially, after calving and before breeding, is a part of managing a successful cow-calf operation (Vestal et al. 2017b). A BCS of 5-6 is the ideal score to maintain for cows because it resembles a healthy cow with a higher chance of pregnancy at rebreeding (Figure 3). To maintain a BCS of 5-6, proper nutrition and forage management is required.

Figure 3. Percent rebred at next breeding season per day, according to BCS at calving
Source: (Field and Sand 1994) (Lalman, Selk and Stein 2017)




Due to drought conditions in 2022, producers in Oklahoma and in many other states in the Great Plains region, have been forced to liquidate their herds. Figure 4 conveys the decline of the beef cow herd in Oklahoma due to producers not being able to feed as many cows on the insubstantial amount of forage and hay available. With more culled cows and lighter weight calves being transitioned from the pasture to packing plants, the supply of beef is increasing in terms of short-run supply. However, in the next few years as producers begin to rebuild, it is anticipated that beef supply will decrease resulting in an increase of prices (Figure 5).

Figure 4. U.S. Beef Cow Inventory 1986-2022
Data Source: USDA-NASS
Graph created by: Derrell Peel

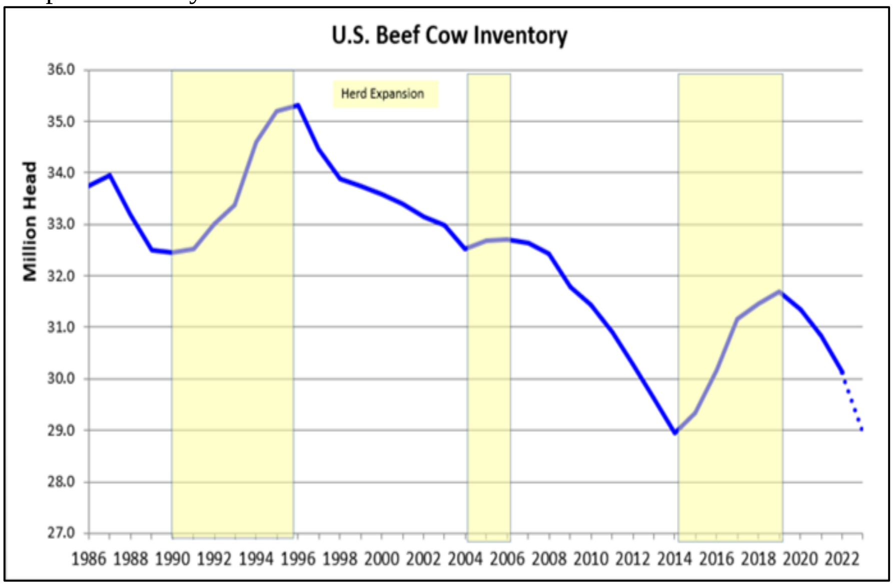
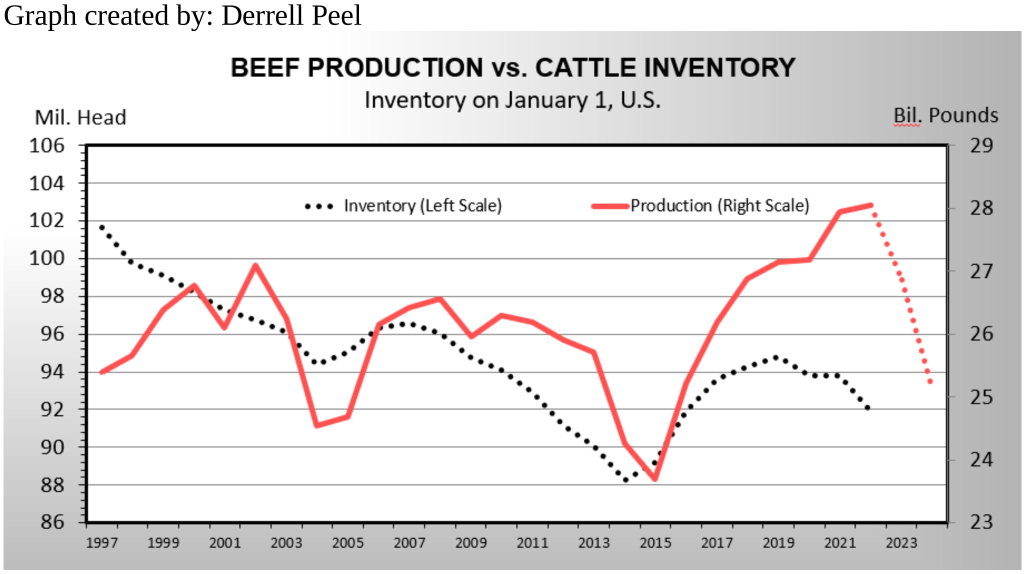



Figure 5. Beef Production vs. Cattle Inventory
Data Source: USDA-NASS, Compiled and Forecasts by Livestock Marketing Center
Graph created by: Derrell Peel

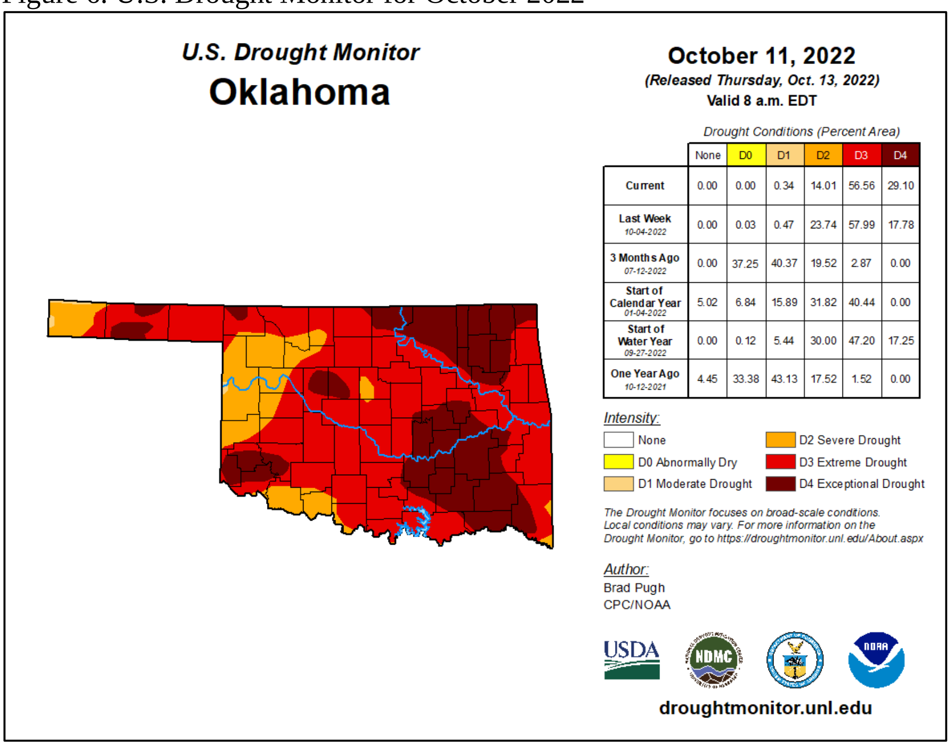



## Drought in Oklahoma

Proper planning and management of rangelands before, during, and after a drought period are vital to forage and cattle production. The severity of drought affects the land in different ways. Abnormally dry conditions can result in stressed crops and late germination, while exceptional drought conditions cause the ground to crack resulting in scarce resources, higher input costs, failed crops, and herd liquidation. Trends shows that exceptional drought conditions occur in Oklahoma every three to four years, with moderate drought conditions occurring every one to three years (NIDIS 2022).

In 2022, 100% of Oklahoma experienced abnormally dry conditions, with 3.1 percent experiencing exceptional drought conditions, making 2022 the 40th driest year to date in the past 128 years (Figure 6). Over three million people were affected by drought in Oklahoma. The longest drought period, since 2000, lasted 239 weeks from early November in 2010 until late May in 2015. During this period, the first week of October in 2011 is recorded as the most intense period of drought with 69.82% of Oklahoma experiencing exceptional drought conditions (Figure 7) (NIDIS 2022).

Figure 6. U.S. Drought Monitor for October 2022

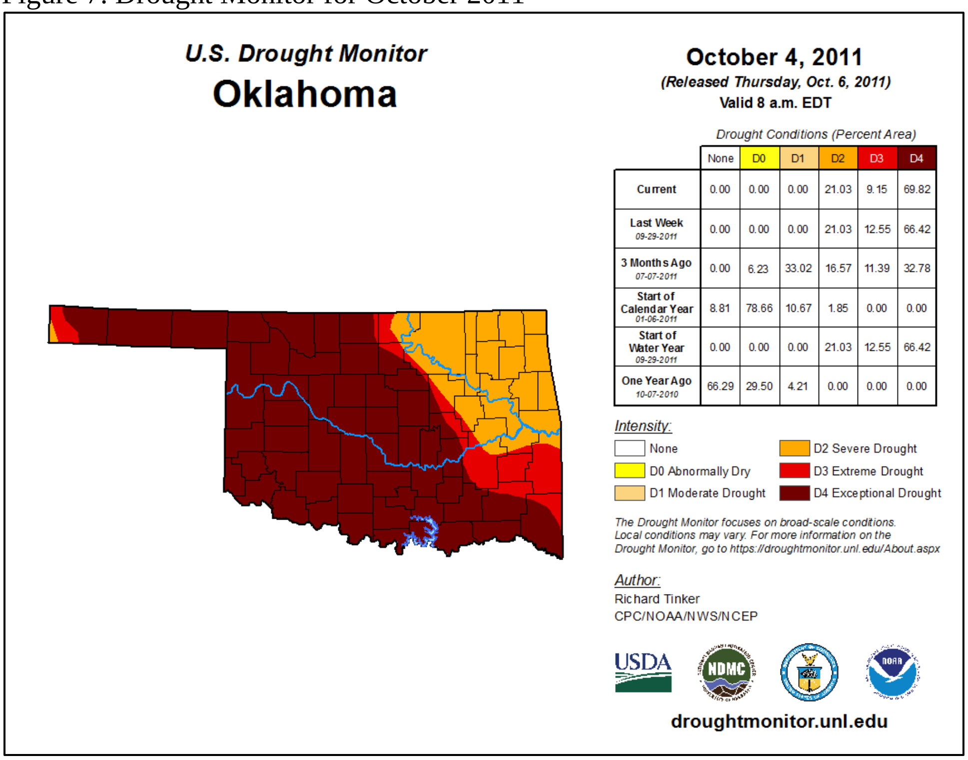


The severity of the drought in 2011 resulted in pastureland not being able to regenerate and sustain livestock. Herd liquidation, increased feed costs, and reduced weight gain were unfortunate consequences of decreased forage availability (Table 1). Oklahoma beef cow numbers declined by 14.3 percent from January 2011 to January 2012, contributing to a 3.1 percent loss in the U.S. beef cow herd (Doye et al. 2013). Drought quickly becomes expensive for cattle producers. The impact of drought affects the productivity of vegetation on rangelands, ultimately affecting the economic feasibility of cattle production. Preemptive rangeland management practices can equip cattle producers to be better prepared for a drought by preventing or reducing potential losses.

Table 1. Losses and Increased Costs due to 2011 Drought (Shideler et al. 2012)

| | |
|---|---|
| Beef Cow Herd Decline | 14.3% |
| Lost Pasture Production | $160 million |
| Additional Feed Costs | $332.6 million |
| Total Cattle-Related Loss | $707 million |

Figure 7. Drought Monitor for October 2011



The repercussions of drought can also vary in severity depending on the effectiveness and diligence of prior planning. Cattle producers cannot stop a drought from occurring, but they can be prepared by being familiarized with historical weather trends, current input costs, and calculating current carrying capacity of rangeland and anticipating a decline in grazeable forage. Well managed rangelands will maintain forage longer in drought. Awareness of these external factors gives cattle producers the means to develop an effective rangeland management system. An effective rangeland management plan developed in preparation for a drought can potentially save an operation from detrimental setbacks.

## **Pyric-herbivory/Patch-burning and Grazing**

Maximizing profit is the primary objective of livestock producers in terms of long-term sustainability and conservation of rangeland resources (West 1993). Forage management influences the profit maximization of cattle production, which is the predominant use of rangelands worldwide (McGranahan et al. 2012). Compensating for limited forages due to situations such as overstocking, drought, and woody plant encroachment (WPE) can become costly, so producers must develop strategies that minimize supplemental inputs (Delcurto et al. 2000). Pyric-herbivory, the interaction between fire and grazing, is a strategy that accomplishes this goal. The utilization of pyric-herbivory can be implemented through patch-burning and grazing (PBG) or by using a traditional approach. Both practices take advantage of using fire to maintain forage growth on rangelands. PBG is implemented by dividing a pasture into sections with one section being burned each year in a rotation, typically taking three years to complete a full rotation (Figure 8) (Figure 10). In comparison to a more traditional approach of burning an entire pasture every three years (Figure 9), PBG potentially offers advantages that benefit both the environment and cattle production.

Figure 8. Patch-Burning and Grazing

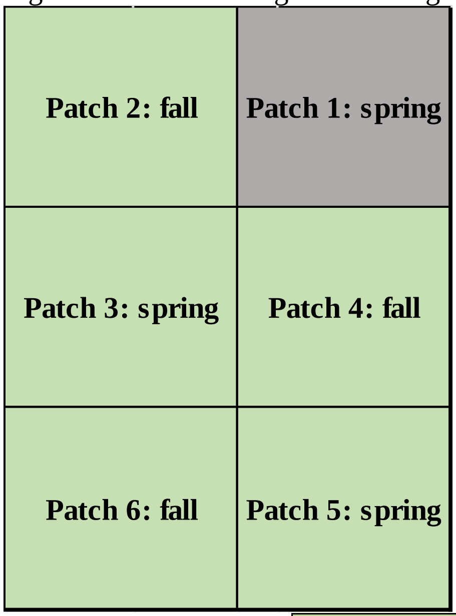
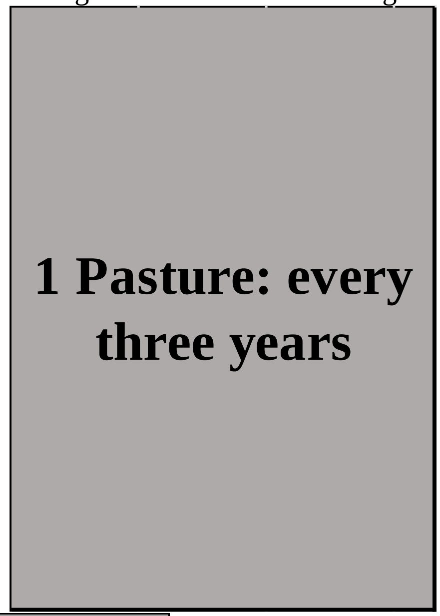



Figure 9. Traditional Burning




*Not burned* | *Burned*

Figure 10. Patch-burn site at OSU Research Range Station
Stillwater, OK August 2022

Research on pyric-herbivory and cattle performance in grassland ecosystems finds that patch-burning creates a pattern in pastures that provides continual access to relatively high-quality forages, resulting in potential decreases in supplemental feed requirements (Limb et al 2011). PBG also leads to woody species control, improved range productivity, and forage stockpiles to mitigate drought impacts. Increases in both forage quality and quantity allow producers to defer from providing supplemental feed early in the winter months, resulting in reduced input costs and a potential increase in profits. Stockpiled forages from previously burned pastures offer drought impact mitigation as cattle can graze the unburned areas. Rangelands are improved because patch-burning limits the spread of red cedar trees. Additionally, without the fuel of woody plants such as eastern red cedar, wildfires can be better controlled and potentially prevented.

Fear of wildfires and liability risks are main reasons why producers are skeptical in utilizing fire as a land management tool at all. For producers who do use prescribed fire, unawareness and rejection of a new practice from seasoned producers are two reasons why there is a lack of adoption of patch-burning and grazing. A survey sent out to private landowners across the states of Texas, Nebraska, Kansas, and Oklahoma concluded that over 90% of respondents did not adopt patch-burning and grazing, and more than half were not aware of it (Adhikari et al. 2023). The benefits of patch-burning and grazing are evident in research. However, this conservation-based management tool is little adopted by cattle producers. The goal of this study is to estimate the costs and quantify the benefits of patch-burning and grazing. The desired outcome is to increase the level of awareness and provide beneficial economic information to potentially increase the adoption of patch-burning and grazing by Oklahoma cow-calf producers.

## **Objectives**

Research has been conducted studying the benefits and effects of patch-burning and grazing on the ecosystem, livestock, plants, pollinators, water and soil, and wildlife for over 50 years. The seminal paper written in 1964 by Duvall and Whitaker discussed how prescribed fires can be utilized without deferring grazing for livestock through pyric-herbivory. There is little research, however, discussing the costs and long-run economic benefits of patch-burning and grazing. Past studies provide the beneficial physical attributes of pyric-herbivory but lack an extensive breakdown of the cost to implement such management practices. The objectives of this study are

1) to estimate the cost of utilizing pyric-herbivory through the implementation of patch-burning management practices, 2) to quantify the qualitative benefits of patch-burning to cattle producers, and 3) to compare annual cost budgets for both patch-burning and grazing and traditional burning on cow-calf operations.

Results from these budgets are used to construct a cost-benefit analysis to justify the initial costs and convey long-term benefits of patch-burning for forage and cattle production. The overall goal of this research is to determine whether patch-burning and grazing can potentially be cost reducing and beneficial to cattle producers when considered as a long-term investment practice.

# CHAPTER II

## LITERATURE REVIEW

Rangelands developed under the influences of both grazing and fire (Bidwell and Woods 2002). Grazing animals such as wildlife, bison, and cattle are attracted to recently burned areas because of higher quality forage provided after the burn. Native Americans observed this response from animals after a fire would occur due to a lightning strike and began using it to their advantage. This strategy for grazing management, known today as pyric-herbivory, is what shaped the heterogenous rangelands across Oklahoma and the Great Plains region. In opposition to this, a more homogeneous management style has been implemented among cattle producers through rotational grazing and herbicide application to create uniformity across pastures. However, lack of diversity in a pasture has the potential to hinder livestock production rather than improve it by altering the natural, heterogeneous landscape across native rangelands (Fuhlendorf and Engle 2001).

Pyric-herbivory – the ecological disturbance created by fire-grazing interactions – depends on fire to influence grazing behavior (Fuhlendorf et al. 2009). Utilizing fire to influence grazing patterns allows certain areas in a pasture to rest, preventing forage loss from overgrazing. Additionally, these rested areas produce stockpiled forages that provide mitigation when forages in the burned areas are not able to emerge as quickly (Allred et al. 2014). Woody plant species, such as large (>6 ft.) Eastern red cedar trees, can hinder an efficient burn because of reducing the among of fuel, dead plant litter, needed to carry a burn (McGranahan et al. 2012). Patch-burning is an alternative method of managing young cedar trees (<6 ft.) before they mature so that forages are not overshadowed. Patch-burning has the potential to improve rangelands while also enhancing cattle production if implemented correctly.

To further examine the impact of patch-burning and grazing (PBG) adoption, a cost-benefit analysis is needed to compare the cost of burning with the potential reduction in costs of supplemental feed. Cost-benefit analyses have historically been one of the most comprehensive forms of economic evaluation for decision making (Robinson 1993). Additionally, historical weather data and forage productivity data is used to estimate the return on investment of patch-burning during a drought. Illustrating costs and potential savings from PBG will aid cow-calf producers in making rangeland management decisions.

## Benefits of Patch-Burning and Grazing

**Forage Quality.** The quality of forages remains at its highest level up to 150 days after being burned (Allred et al. 2011). The quality of forages can be defined by the extent to which a forage has the potential to produce a desired animal response. Nutrient content, intake, digestibility, and animal performance are factors that influence forage quality. As plants mature, they become less desirable to cattle. When forage intake declines, digestion declines ultimately leading to a decrease in absorption of nutrients (Ball et al. 2001). Cattle producers must then intervene and provide some form of supplement to meet nutrient requirements.

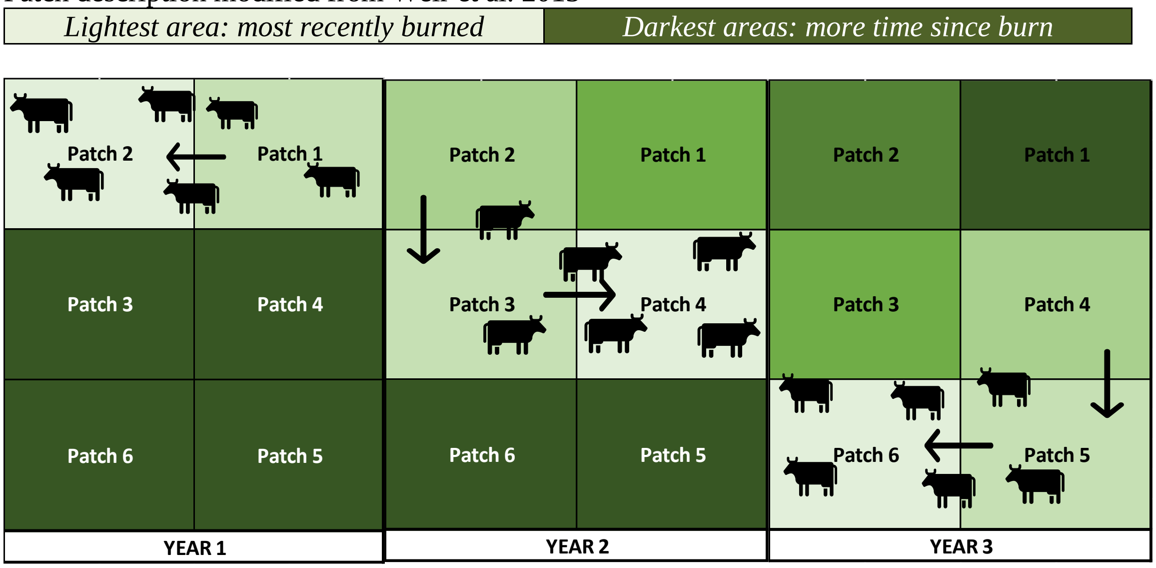
Supplemental feed costs exceed more than half of the direct cost in cow-calf operations (Short 2001). Producers can reduce the reliance on supplemental feed by providing continual access to high quality forage for cattle by utilizing patch-burning. When implementing patch-burning and grazing for cow-calf pairs, it is recommended to burn two patches a year: one in early spring and the second at the end of the summer months (Weir et al. 2013). Burning two patches a year creates frequent access to higher quality forage for cows and calves throughout stages of gestation and growth. Research conducted comparing cow-calf pairs on patch-burned pastures and traditionally burned pastures supported this claim. Cows on patch-burned pastures required 40% less in supplemental feed requirements in comparison to cows on traditionally burned pastures. Burning in the late summer months allowed for the cows to graze higher quality forages through the transition to the fall season and before the harsh winter months (Limb et al. 2011).

Crude protein is a common measurement used to determine forage quality in cattle production. The requirement for crude protein increases as energy requirements increase (Maas 1987). For example, a 1,000 pound lactating cow requires more crude protein (8.7-12.3%) than a dry 1,000 pound cow in her middle trimester of pregnancy (7.1%) (Harty 2020) . In the tall-grass prairie near Pawhuska, Oklahoma, crude protein levels in burned areas were 16.9% in comparison to 4.1% in unburned areas (Scasta et al. 2016; Allred et al. 2011). According to a study conducted in North Dakota, crude protein levels exceeded livestock nutrient requirements in recently burned patches than in unburned patches. Burning twice a year (spring and fall) with an optimal stocking rate, cow-calf producers can take advantage of high crude protein levels in recently burned areas and stockpiled forage in unburned areas to create a favorable heterogeneous landscape (Spiess et al. 2020).

**Drought Impact Mitigation**. Precipitation plays a major role in the productivity of cattle operations. Rainfall influences forage production, which influences cattle production. Past studies show that higher cattle production is associated with greater precipitation and cooler temperatures during spring months (Reeves et al. 2014). Temperatures are expected to increase and precipitation is predicted to decrease in the GP region (Karl, Melillo and Peterson 2009). Severe droughts reduce livestock productivity (Lockeretz 1978). Pyric-herbivory management practices, such as patch-burning and grazing, can mitigate losses due to drought or other weather extremes by maximizing forage quality in recently burned areas while maintaining forage quantity in other areas of a pasture (Allred et al. 2011). Reduced rainfall will likely affect cattle production, but patch-burning can mitigate the negative effects of decreased forage availability on weight gain during drought years. Research was conducted over a six-year period in northeastern Oklahoma rangeland pastures maintained by patch-burning that were not dependent on precipitation to convey that heterogenous management can provide stability and mitigation for the expected increase of variability in rainfall. Results showed that weight gain of the cattle did not differ between pastures that were burned as a whole, and pastures burned in patches. The use of the fire-grazing interaction provides stability and potential improvement in weight gains during drought years by providing diversity in the forages that cattle consume. (Allred et al. 2014).

Results from a study conducted in northeastern Oklahoma show that cattle prefer to graze recently burned areas, allowing unburned areas to rest to provide an adequate amount of fuel (forage) for the next patch to be burned. The unburned and ungrazed areas provided a lower forage quality, but more forage availability for cattle when a new patch is being burned (Allred et al. 2014) (Figure 11). Patch-burning creates a pattern of heavier grazed areas with lower forage biomass but higher crude protein levels and ungrazed areas with higher forage biomass but lower crude protein levels (Spiess et al. 2020). Stockpiled forages potentially offer an alternative to providing supplemental feed or destocking during a drought season.

Figure 11. Cattle rotating to recently burned patches each year with two patches burned per year (late spring & early fall)
Patch description modified from Weir et al. 2013




Optimal stocking rates are necessary for patch-burning to be effective and beneficial as a drought impact mitigation strategy. Overstocking is one of the leading factors that affects fuel levels, potentially hindering a successful burn (McGranahan et al. 2012). Cattle managers have been resistant to adopt conservation-based practices like patch-burning because of the possibility of having to reduce stocking rates (Limb et al. 2011). Studies show that moderate stocking rates are required for maximizing net return. Optimal stocking rates vary for every operation. Stocking rate can be expressed as animal units/unit of land area/unit of time. Carrying capacity is the stocking rate that is sustainable over many periods. Optimal stocking rates correlate with rangeland and pasture carrying capacity (Weir et al. 2013). Research suggests that while the benefits of pyric-herbivory vary across different operations, it can be practiced without reducing livestock production or profitability (Limb et al. 2011).

Inefficient stocking rates, combined with a lack of precipitation, can affect the natural rotation of cattle moving through recently burned patches. Limited forage production from a drought will reduce the attractiveness of a burned patch, resulting in cattle relying on and grazing unburned areas (McGranahan et al. 2012; Spiess et al. 2020). Grazing the unburned areas will decrease forage biomass and ultimately affect the success of the next burn (Scasta et al. 2016). Calculating stocking rates prior to and during the grazing season of a drought is essential to the effectiveness of patch-burning. Overstocking during a drought can increase the risk of limited forage, causing cattle to graze to rely even more on the unburned areas. This results in a more homogenous landscape, defeating the purpose of patch-burning (Augustine and Derner 2014). Patch-burning and grazing offers mitigation for drought impacts as long as there is diversity in a pasture that allows cattle access to both high quality and quantity of forages.

**Woody Plant Encroachment and Wildfire Control.** It is estimated that Oklahoma is losing approximately 278,130 acres per year to red cedar trees (Smith 2011). The invasion of red cedar, along with other invasive species, is a direct result of fire suppression and poor land management. According to the 2002 State Technical Committee for USDA Cost Share Programs, red cedar has become the number one conservation concern. The increase of woody plant encroachment (WPE) is taking over grazeable rangelands and limiting forage productivity. The continuance of fire suppression will further hinder the sustainability of rangelands if the use of fire is not implemented as a management tool to control WPE. Additionally, large woody plant species fuel and increase the intensity of wildfire if not managed in a timely manner (Agrilife Today 2021). Red cedar and other junipers are intolerant to fire. Therefore, once larger plants are removed either mechanically or by burning, consistent burning will successfully prevent the invasive species from reemerging (Bidwell and Weir 2017).

Prescribed fire is one of the best management practices for controlling and preventing red cedar from taking over rangelands (Bidwell and Weir 2017). Patch-burning used in tandem with grazing has shown to be one of the most beneficial ways to use prescribed fire without deferring grazing for livestock (Duvall and Whitaker 1964). Grazing animals also help to control woody plant species in between burns (Agrilife Today 2021). After burning, other invasive species such as sericea lespedeza, are more palatable causing cattle and other livestock to be able to graze them (Ohlenbusch 2007; West et al. 2016). Adopting patch-burning and grazing as a rangeland management practice results in a feasible and alternative way to manage rangelands without having to reduce cattle production.

While an adequate amount of fuel is needed to carry a fire when burning an ungrazed patch, the recently burned and grazed patches reduce fuel for wildfires (Weir et al. 2013). Pastures managed using patch-burning and grazing have the potential to reduce fuel accumulations, flame lengths, and rates of spread compared to using fire only. Pyric-herbivory has a negative effect on biomass, meaning there is less fuel to carry a fire, reducing the severity of the flame (Starns et al. 2019). Wildfires can cause significant damage to properties. Consequently, the re-establishment of prescribed fire through the practice of pyric-herbivory has the means of providing a safe and efficient way of reducing the spread of wildfire to protect cattle operations.

## Cost-Benefit Analysis

Cattle production requires producers to make a series of complicated and intertwined decisions that impact their bottom line, the environment, and the cattle industry. Providing cow-calf producers with beneficial economic information about patch-burning and grazing is the goal of this research. Therefore, a cost-benefit analysis is used to address at least one of these complicated and intertwined decisions producers must make to preserve rangelands and maintain the cattle industry.

**Definition.** Cost-benefit analysis is the systematic and analytical process of comparing benefits and costs in evaluating the desirability of a project to estimate if a project is worthwhile (Mishan and Quah 2020). For the cost-benefit analysis being constructed for patch-burning and grazing, the stated preference approach will be used since this approach is based on an individual's willingness to pay. The stated preference approach is when a person's valuations are placed on an activity by assessing how much money they are prepared to accept for an increased risk (Robinson 1993).

There are nine major steps in building a cost-benefit analysis (Boardman et al. 2017) (Table 1). From reviewing alternative methods to making a final recommendation, a cost-benefit analysis is beneficial in deciding whether a project will be a wise investment. The steps in constructing a cost-benefit analysis for patch-burning and grazing will involve answering similar questions related to the rangeland management practice.

Table 2. Steps in Building a Cost-Benefit Analysis
(Boardman et al. 2017)

| **Steps in a Cost-Benefit Analysis** |
|---|
| 1. Specify the set of alternative projects. |
| 2. Decide whose benefits and costs count (standing). |
| 3. Identify impact categories. |
| 4. Predict impacts quantitatively over life of project. |
| 5. Monetize all impacts. |
| 6. Discount benefits and costs to obtain present values. |
| 7. Compute net present value of each alternative. |
| 8. Perform sensitivity analysis. |
| 9. Make a recommendation. |

**Using Cost-Benefit Analysis for Land Management.** Cost-benefit analyses are commonly used for governmental decisions and social policy (Robinson 1993). However, it has been successfully used in making land management decisions. A comparable cost-benefit analysis was used to discover the best option for controlling invasive annual grasses. The adopted model used was based on measuring vegetation growth in response to different management practices and modeling cost/benefit economics associated with expected forage (Sheley, Sheley and Smith 2014; Griffith and Lacey 1991). This model created results that allowed researchers to make a recommendation on how to best manage invasive grasses while supporting the decision with economic evidence.

This same model was originally used for a study looking at the costs and benefits of utilizing picloram to control spotted knapweed (Griffith and Lacey 1991). The motivation behind this analysis is similar to the motivation behind the analysis for patch-burning and grazing. Individuals were utilizing picloram, but there was little research discussing the economic feasibility of the technique. The cost-benefit analysis model of estimating the economic feasibility and returns among management practices provided monetary answers that were needed to further support the use of picloram to control knapweed. A sensitivity analysis was performed to assess the range of environmental and economic factors (Griffith and Lacey 1991). This part of a cost-benefit analysis is necessary to convey the feasibility of management practices over time. Sensitivity analyses can aid in identifying critical control points, prioritizing additional research, and validating a model (Christopher Frey and Patil 2002). A sensitivity analysis within the cost-benefit analysis will be used to validate and enhance the economic research of patch-burning and grazing.

# CHAPTER III

## METHODOLOGY

By maintaining rangelands through patch-burning and grazing (PBG), cattle producers can improve the profitability and sustainability of cattle production on their operations. Implementing patch-burning and grazing as a forage management practice, provides a risk management procedure to combat high feed costs, woody plant encroachment (WPE), and drought impacts. Past research results emphasize these benefits of patch-burning and grazing, but the utilization of PBG remains scarce. There are many reasons for this outcome, but one method of influence could be to provide a cost-benefit analysis of implementing and utilizing PBG to maintain Oklahoma rangelands. An economic analysis can aid cattle producers in profitable decision making. The analysis required understanding and estimates of burn costs, feed costs, and drought impact mitigation scenarios.

### Burn Costs

The first step in building a cost-benefit analysis for PBG involved estimating the costs of burning for both patch-burning and traditional burning (entire pasture/area every three years). Data from the Natural Resource Ecology and Management (NREM) Department at Oklahoma State University was used to estimate these costs. The 2021 survey asked for information for the years 2016-2020. The data consisted of survey responses from individuals who utilized prescribed fire on their land. Respondents included private landowners, state and federal agencies, tribal governments, non-governmental organizations (NGO), and contract burners. They were asked to provide cost information associated with conducting a burn. Information collected included number of acres burned and how often, estimated annual burn cost, a breakdown of those costs, who conducts the burns, and whether they were a member of a prescribed burn association (PBA).

Costs to consider when considering a prescribed burn include firebreak construction, fuel, labor, contractor costs, and PBA dues. Purchasing equipment is also a possible cost. Firebreak construction is the main expense when conducting any kind of burn followed by fuel and labor. There are different ways to build a firebreak to ensure a controlled burn and the safety of those conducting the burn. Firebreak types included in this survey included mowed lines, disked lines, dozed/blazed lines, existing roads, and natural barriers. The ideal firebreak would be an existing barrier such as roads or creeks to limit costs, time, and labor. However, that is not always the scenario. So, landowners must map out the best plan for burning to build the appropriate, optimal firebreaks for the specific property. This is especially true for patch-burning in contrast to traditional burning since a pasture is being divided into sections.

The goal of the survey was to gather information about the costs of prescribed burning. However, the responses needed to be analyzed accordingly to meet the more specific goal of estimating patch-burn costs in comparison to traditional burn costs. Only responses from private landowners (N=37) were separated and used to estimate costs more accurately for cattle producers. While the survey was not designed for questions specific to patch-burning practices, responses were divided based on the following assumptions:

1) Only landowners who conducted the burn themselves, not through a contractor, were included in the analysis.

2)  Landowners who burned once or twice annually, every year, were assumed to follow patch-burning practices.

3) Landowners who burned more than twice in a year, did not burn every year, or burned a consistent amount of acreage every year, were assumed to follow a more traditional practice of burning.

**Feed Costs**

A study conducted during the years of 2002-2006 (Limb et al. 2011) in tandem with supplemental feed estimates (Lalman 2021) were utilized to build a data set for estimating feed cost comparisons. The study compared spring calving cow-calf pairs on patch-burned pastures to pairs on traditionally burned (TB) pastures, using body condition scores (BCS) and weaning weights as the units of measurement. Patch-burned pastures were burned twice a year (one patch in spring and fall), and traditionally managed pastures were burned in their entirety every three years. Grazing was continuous on 150 acres at the OSU tall-grass prairie research station in Payne County.

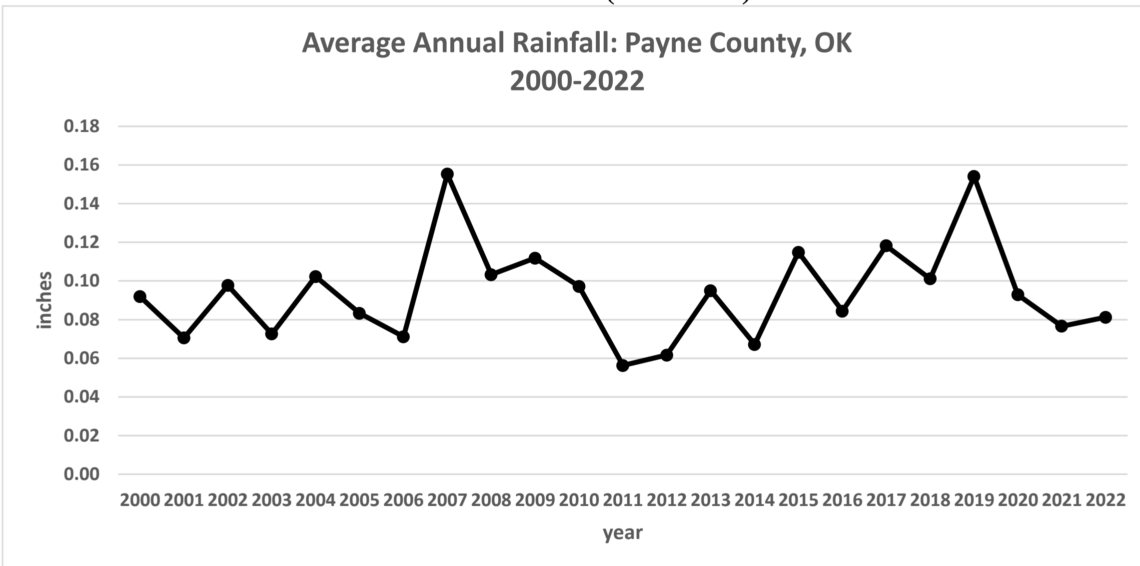
In the analysis published in 2021 (Lalman 2021), supplemental feed costs were estimated for several different scenarios and protein supplements. The cost to feed a 38% protein supplement to cows grazing native rangeland was estimated to cost approximately $0.37 per head per day. The protein supplement fed to pairs in the Limb et al. 2011 study was a 40% protein. Therefore, the cost of a 38% protein supplement was used to estimate feed costs for the analysis of patch-burning and grazing (PBG).

Feed costs for PBG and TB were estimated based on the results from the Limb et al. 2011 study and the feed costs report from Lalman 2021. While there was not a statistical difference in calf weaning weights between the two practices in the Limb et al. 2011 study, cows on patch-burned pastures required 40% less in supplemental feed requirements than cows on traditionally burned pastures. Cows on patch-burned pastures were fed for three months (90 days) compared to cows on traditionally burned pastures being fed for five months (150 days). Burning in the early fall/late summer months allowed for cattle to rely on the high-quality forages for an additional three months rather than a supplement. The recommended rate for feeding a 38% protein supplement is 1.95 pounds per head per day, assuming the native forages are supplying 0.88 pounds of crude protein per day and 10.78 pounds of total digestible nutrients (TDN) per day. Following this recommendation allows for cows to maintain an acceptable BCS throughout the third trimester of pregnancy.

## Mitigation for Drought Impacts

Data sets containing historical rainfall, drought severity, and range productivity were combined to estimate the potential drought impact mitigation offered by patch-burn grazing (PBG). All data used was collected in Payne County, Oklahoma. Historical rainfall data was obtained from the Stillwater Mesonet weather station to represent rainfall in Payne County. Data starts on January 1, 2000, and ended on December 31, 2022, to estimate rainfall over a significant amount of time. The data originally provided daily amounts of rainfall in inches. Daily values were aggregated to represent annual averages of rainfall (Figure 12). Dates where data was unavailable (+/-990-999) were removed to avoid negative averages and sums. The average amount of rainfall over the 22-year period was 0.0943 inches per day with the average sum being 33.9370 inches per year.

Figure 12. Average Daily Rainfall per Year in Payne County, Oklahoma
Data Source: Mesonet - Stillwater Weather Station (2000-2022)



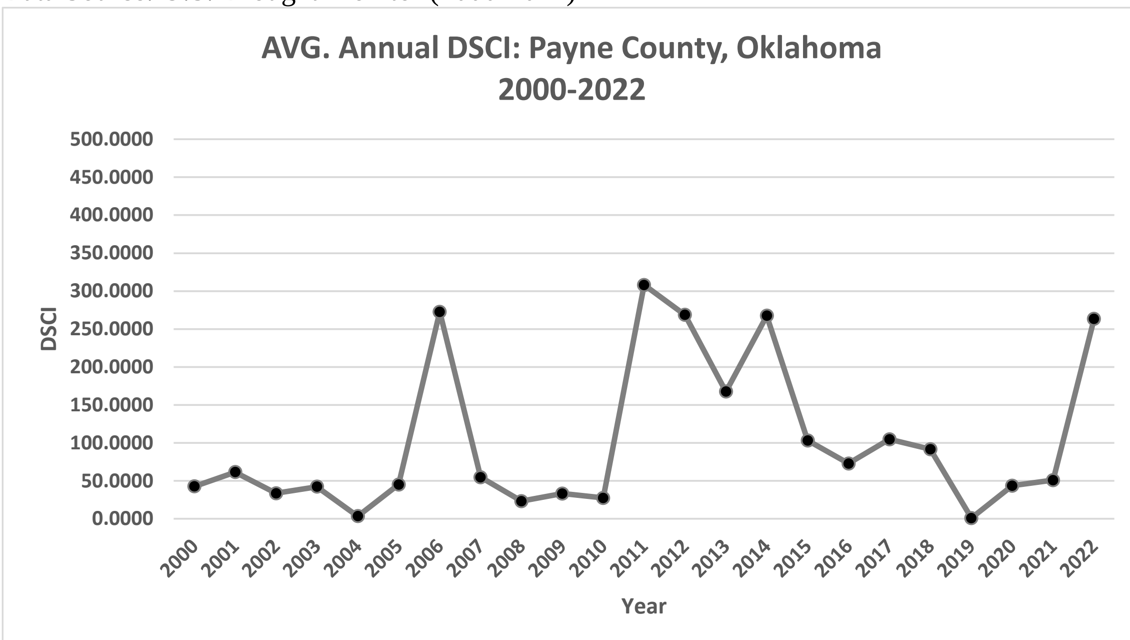

Data conveying drought conditions and severity for Payne County was obtained from the U.S Drought Monitor. The time frame was the same as the rainfall data, 2000-2022. The drought monitor provides different categories of drought based on severity, D0-D4, and an overall index of the area, DSCI. These categories are described in Table 3.

Table 3. Drought Monitor Descriptions
Data Source: U.S. Drought Monitor

| U.S. Drought Monitor Categories | |
|---|---|
| D0 | Abnormally Dry |
| D1 | Moderate Drought |
| D2 | Severe Drought |
| D3 | Extreme Drought |
| D4 | Exceptional Drought |
| DSCI | Drought Severity & Coverage Index; 0-500 with 0 meaning none of the area is abnormally dry & 500 meaning the entire area is in exceptional drought |

Only DSCI values were utilized to best represent the entire area of Payne County. DSCI from the U.S. drought monitor was utilized because data was site specific to Payne County to represent drought impacts at the OSU Range Research Station rather than a general area in Oklahoma. The data set originally provided weekly estimates. These were aggregated to represent annual averages of DSCI values (Figure 13). The average DSCI across Payne County over the 22-year period was 105.76 with the highest index being 307.96 in 2011.

Figure 13. Average Annual DSCI for Payne County, Oklahoma
Data Source: U.S. Drought Monitor (2000-2022)




Forage production was estimated utilizing data from the Web Soil Survey provided by the United States Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS). The tall-grass prairie on the OSU Range Research Station in Payne County, roughly 5,000 acres, was selected as the location. The area consists of eroded fields that were abandoned in 1950 (Limb et al. 2011). Vegetative productivity is classified into three categories based on annual precipitation: normal, favorable, and unfavorable. The tall-grass prairie on the range station contains several different soil types (~25). Therefore, an average value of all soil types was calculated to represent forage productivity for each classification (Table 4). For estimating mitigation in the cost-benefit analysis, the years 2003-2006 were each assigned one of these classifications based on the amount of rainfall received in the given year (Table 5). These specific years were used to resemble the period of the Limb et al. 2011 study.

Table 4. Average Range Production at OSU Range Research Station
Data Source: Web Soil Survey

| **Avg. Range Production – OSU Range Research Station Payne County, Oklahoma (pounds per acre)** | |
|---|---|
| Normal Year | 4013 |
| Favorable Year | 5222 |
| Unfavorable Year | 2577 |

Table 5. Classification Assumptions for 2003-2006 based on DSCI & Web Soil Survey

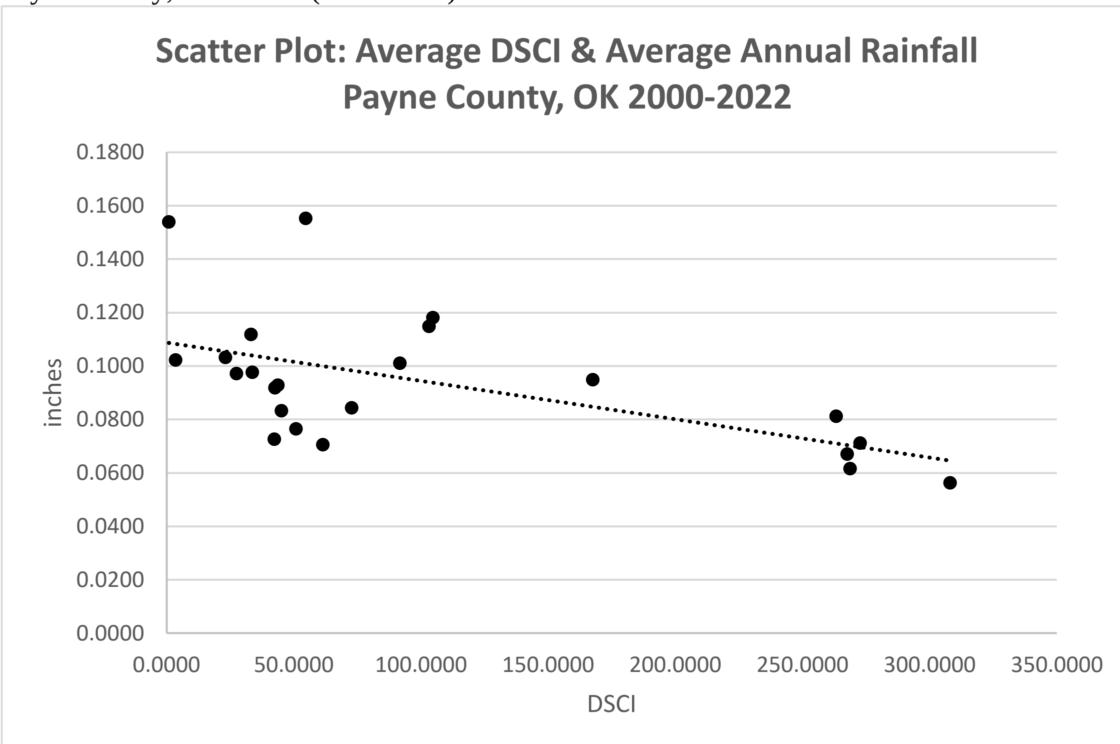
| **Range Productivity Classifications** | | | |
|---|---|---|---|
| **Year** | **DSCI** | **Category** | **Forage Production** |
| 2003 | 42.2692 | Normal | 4013 |
| 2004 | 3.4423 | Favorable | 5222 |
| 2005 | 45.0385 | Normal | 4013 |
| 2006 | 272.6923 | Unfavorable | 2577 |

Correlations among each of these data sets were calculated to ensure and reiterate the relationships among rainfall, drought, and forage productivity. As expected, all correlations exhibit strong relationships between variables (Table 6). Correlation 1) conveys that as rainfall decreases, the range of exceptional drought in the area increases (Figure 14). Correlation 2) conveys a similar outcome showing as DSCI increases, forage productivity decreases at almost the same rate. The strong correlation between DSCI and forage further supports the use of DSCI to best represent the relationship between drought and forage production. Lasty, correlation 3) emphasizes a strong positive correlation showing an increase in rainfall results in an increase in forage.

Table 6. Correlations among Drought, Rainfall, and Forage Variables

| **Correlations** | |
|---|---|
| 1) DSCI & Rainfall | -0.5621 |
| 2) DSCI & Forage | -0.9211 |
| 3) Rainfall & Forage | 0.8617 |

Figure 14. Scatter Plot of Average Annual DSCI & Daily Average Rainfall per Year Correlation Payne County, Oklahoma (2000-2022)




Correlations involving the forage productivity variable show to be the strongest, emphasizing the known fact that weather conditions actively affect rangelands used for grazing. As a result, cattle producers must implement strategies to combat the effect of limited forage before substantial damage is done.

One benefit that patch-burning and grazing (PBG) offers as a rangeland management practice is drought impact mitigation by providing stockpiled forages in unburned and ungrazed areas. However, drought conditions can affect the consistency and schedule of burning for producers whether they are using traditional burning (TB) or PBG (Figure 15 and Figure 16). Five different comparison scenarios were developed to address the cost differences between potential outcomes of PBG and TB during a drought (Table 7).

Figure 15. Patch-Burning Options during Drought

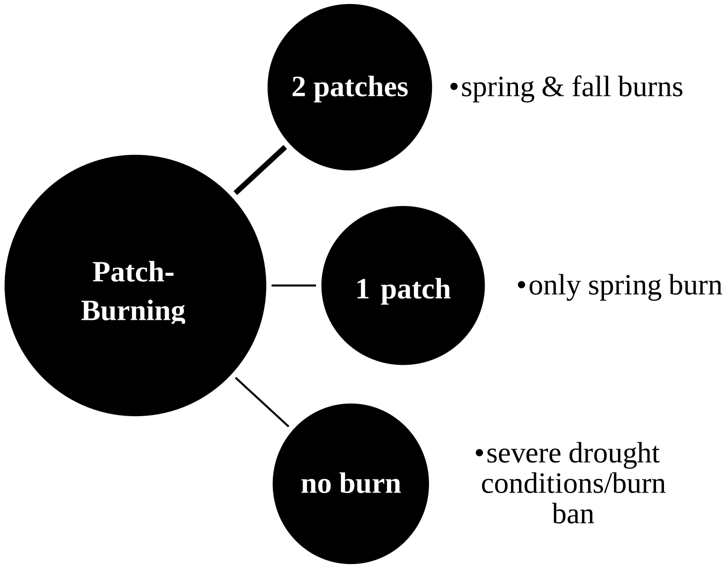



Figure 16. Traditional Burning Options during Drought

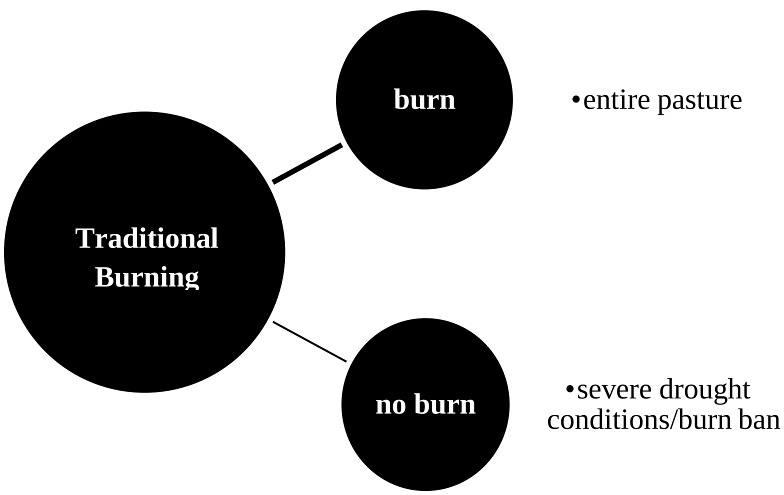


Table 7. Scenarios for Burning Options during Drought

| Scenarios | Traditional Burning | Patch-Burning |
|---|---|---|
| 1 | Burn | 2 Patches |
| 2 | Burn | 1 Patch |
| 3 | No burn | 2 Patches |
| 4 | No burn | 1 Patch |
| 5 | No burn | No Burn |

The first step in adopting a new management practice requires producers to compare the outcomes of each option. Forage productivity in different years with varied weather effects were used to compare PBG results to TB results. Forage in stockpiled areas was estimated using the average pounds per acre of range productivity from Web Soil Survey. The amount of acreage (150 acres) and stocking rate (8 cow-calf pairs) was adopted from Limb et al. 2011 to calculate potential mitigation of drought impacts from PBG on the OSU Range Research Station. Analyses from each data set were combined to construct estimations of available forage in stockpiled areas per year during normal, favorable, and unfavorable years for both PBG and TB (Table 5 and Table 8). Comparing forage productivity for all possible conditions creates an overall perspective of what each management practice offers. Once all outcomes have been evaluated for all weather categories, a decision can be made that is most beneficial for a producer’s cow-calf operation.

Table 8. Forage Availability in Burned and Unburned Patches for PBG and TB based on frequency and timing of burns
[a]details in Appendix

| [a]Year | Total Forage (lbs/year) | High-Quality Forage (lbs/year) | Stockpiled Forage (lbs/year) |
|---|---|---|---|
| | **PBG: 2 patches** | | |
| 2003 | 601,950 | 200,650 | 401,300 |
| 2004 | 783,300 | 261,100 | 522,000 |
| 2005 | 601,950 | 200,650 | 401,300 |
| 2006 | 386,550 | 128,850 | 257,700 |
| | **PBG: 1 patch** | | |
| 2003 | 601,950 | 100,352 | 501,625 |
| 2004 | 783,300 | 130,550 | 652,750 |
| 2005 | 601,950 | 100,352 | 501,625 |
| 2006 | 386,550 | 64,425 | 322,125 |
| | **TB: entire pasture** | | |
| 2003 | 601,950 | 601,950 | 0 |
| 2004 | 783,300 | 783,300 | 0 |
| 2005 | 601,950 | 601,950 | 0 |
| 2006 | 386,550 | 386,550 | 0 |
| | **TB: not burning** | | |
| 2003 | 601,950 | 0 | 601,950 |
| 2004 | 783,300 | 0 | 783,300 |
| 2005 | 601,950 | 0 | 601,950 |
| 2006 | 386,550 | 0 | 386,550 |

The next step is to compare the level of mitigation that both practices provide by measuring nutrient requirements met and needed based on forage availability. All drought scenarios are comparable outcomes between patch-burning and grazing and traditional burning. Estimates aid cattle producers in making the decision on if and how to burn during an unfavorable year to take advantage of maximum forage availability. Forage growth will be dependent on rainfall. If drought severity increases, access to high quality forage will be limited in burned patches. Therefore, to convey worst case scenario, estimates of forage availability in a pasture will be calculated using only forage quantity in stockpiled patches. The first two scenarios compare burning an entire pasture to burning either one or two patches. Scenarios three and four compare not burning an entire pasture to burning either one or two patches. The last scenario includes the decision to not burn at all using either burn practice.

Scenario 1**.** The first drought scenario involves burning two patches using patch-burning, one in spring and one in late summer (Figure 17). Traditional burning will involve burning the entire pasture since it is assumed this is year one of the burn rotation.

Figure 17. Scenario 1 Pasture Layout

| | |
|---|---|
| **Patch 2: highest quality** | **Patch 1: high quality** |
| **Patch 3: stockpiled** | **Patch 4: stockpiled** |
| **Patch 6: stockpiled** | **Patch 5: stockpiled** |

Scenario 2**.** The second drought scenario involves deciding to only burn one patch in the spring when using patch-burning (Figure 18). Forage on traditionally burned pasture will be the same as scenario one.

Figure 18. Scenario 2 Pasture Layout

| | |
|---|---|
| **Patch 2: stockpiled** | **Patch 1: high quality** |
| **Patch 3: stockpiled** | **Patch 4: stockpiled** |
| **Patch 6: stockpiled** | **Patch 5: stockpiled** |

Scenario 3. In this scenario, drought conditions are too severe for traditional burning because the pasture is too large to burn all at once. Patch-burning can still be permitted since it is a smaller area and is easily controlled (Weir, Stevens and Bidwell 2017). A cattle producer may still decide to burn two patches using patch-burning. Therefore, outcomes of forage will be like scenario one (Figure 17).

Scenario 4. In this scenario, drought conditions are too severe for traditional burning and severity is expected to increase throughout the summer months. As a result, the cattle producer utilizing patch-burning decides to only burn a single patch in the spring. Therefore, the pasture layout of patch-burning for this scenario will be the same as scenario two (Figure 18).

Scenario 5. In this final scenario, drought conditions are severe and prohibit burning for both management practices (Figure 19). Cattle will have access to the stockpiled, low-quality forage in both pastures. However, stockpiled patches decrease in variability over time (Bielski et al. 2018). Forage growth remains dependent on rainfall, meaning forage availability will steadily decrease as cattle continually graze forage.

Figure 19. Scenario 5 Pasture Layout

| | |
|---|---|
| **Patch 2: stockpiled** | **Patch 1: stockpiled** |
| **Patch 3: stockpiled** | **Patch 4: stockpiled** |
| **Patch 6: stockpiled** | **Patch 5: stockpiled** |

## Cost-Benefit Analysis

Patch-burning and grazing (PBG) offers several benefits, but they need to be quantitatively estimated to justify the potential long-term savings. Estimations of burn costs, feed costs, and mitigation of drought impacts will be utilized to compare six-year cost-benefit analyses of PBG and traditional burning (TB). The process of constructing both analyses will involve addressing the nine steps listed in Table 1 (Table 9). Identifying the alternative rangeland management projects, monetizing impacts, computing a net present value, and performing a sensitivity analysis will allow for a recommendation to be made for Oklahoma cow-calf producers on how to best manage their rangelands.

Table 9. Steps in Building a Cost-Benefit Analysis for PBG and TB
Addressing the nine steps of a Cost-Benefit Analysis (Table 1) (Boardman et al. 2017)

| **Steps in a Cost-Benefit Analysis for Rangeland Management Practices** |
|---|
| 1. Patch-Burning and Grazing and Traditional Burning |
| 2. Costs and benefits that affect cow-calf producers in Oklahoma |
| 3. Costs: burn costs for patch-burning and grazing and traditional burning<br>Benefits: reduced feed costs and mitigation for drought impacts |
| 4. Cost of burning and feeding over six-year period<br>Measurement of forage availability during a drought year |
| 5. Monetize all impacts. |
| 6. Discount benefits and costs to obtain present values. |
| 7. Compute net present value of each alternative. |
| 8. Perform sensitivity analysis. |
| 9. Make a recommendation. |

# CHAPTER IV

# RESULTS

Results for burn costs, feed costs, and potential mitigation for drought impacts are computed separately and used to construct a six-year cost-benefit analysis comparing patch-burning and grazing (PBG) and traditional burning (TB). A sensitivity analysis is conducted along with calculated net present values (NPV) to resemble future value savings of each alternative method. Estimating long-term costs and benefits of both rangeland management practices provides economic information for Oklahoma cow-calf producers to make an informed decision.

## Burn Costs:

Based on landowner responses from the 2021 survey providing the cost of conducting each burn, cost per acre was able to be estimated for both rangeland management practices. Averages based on assumptions were calculated for number of burns conducted annually, cost of annual burns, and number of acres burned. The number of burns conducted for PBG averaged 1.10 burns per year. The number of burns conducted for TB averaged 3.33 burns per year. It is assumed that several burns were needed to cover a larger area or there was a lack of labor. The average cost per acre per year was calculated using the annual average number of acres and average costs of burning (Table 10).

Table 10. Annual Average Cost per Acre for PBG and TB
Data Source: 2021 Prescribed Burning Costs (OSU NREM)
Aaron Russell, Omkar Joshi, and John Weir

| Annual Averages | Patch-Burning | Traditional Burning |
|---|---|---|
| **Number of Acres Burned** | 133.41 | 862.45 |
| **Cost of Burn** | $610.47 | $1,558.83 |
| **Cost per Acre** | $4.58 | $1.81 |

Based on these calculations, it is concluded that patch-burning and grazing (PBG) will cost more than traditional burning (TB) by approximately $2.77 per acre. After estimating annual cost per acre, these estimates were used to construct an analysis of cost breakdowns (Table 11). The conclusion that firebreak construction is the largest expense when burning was supported in both PBG responses and TB responses. Fuel and labor were the second and third largest percentage of costs. Of the PBG respondents, 77% utilized mowed lines and 66% utilized existing roads and natural barriers. Of the TB respondents, 76% utilized existing roads, 72% utilized mowed lines, and 64% utilized natural barriers. This explains why fuel costs are slightly higher for PBG representing roughly 19% of burn costs compared to only 16% in TB. One respondent stated 60% of his costs were classified as other. It is assumed that this category was high due to the respondent having to buy equipment to conduct burns since he was not a member of a prescribed burn association (PBA). Being a member of a PBA provides for producers to work together to conduct burns, allowing for shared equipment and labor. Other costs for producers could include purchasing any necessary permits or insurance.

Table 11. Burn Cost Estimates for PBG and TB
*(Total Avg. Cost/Acre * Cost Breakdown %) = Cost Per Acre*

| Costs | Breakdown % | Cost/acre |
|---|---|---|
| | **Patch-Burn** | |
| Firebreak Construction | 38.6% | $1.77 |
| Labor | 30.0% | $1.37 |
| Fuel | 19.2% | $0.88 |
| PBA Dues | 5.4% | $0.25 |
| Other | 28.0% | $1.28 |
| **Total** | | **$4.58** |
| | **Traditional Burn** | |
| Firebreak Construction | 62.0% | $1.12 |
| Labor | 18.9% | $0.34 |
| Fuel | 16.1% | $0.29 |
| PBA Dues | 8.8% | $0.16 |
| Other | 11.0% | $0.20 |
| **Total** | | **$1.81** |

Burn costs for years two and three were then estimated based on the average value assigned to each element of the cost breakdown. It is anticipated that firebreak construction costs will decrease after implementation year one (Weir et al. 2013). Based on the assumption that four sides of a patch had to be burned in year one, then the next year only three sides would need to be burned. This assumption is made because the following patch can be burned into the previously burned patch that does not contain enough fuel to carry the fire. Each side would require a firebreak to be constructed if a natural barrier was nonexistent. After a full rotation (~ three years), firebreak construction on the first patch may have to be reconstructed. However, after several years of a full patch-burning rotation, firebreaks should become more permanent. Estimated annual firebreak construction costs for years one through three for both PBG and TB in a pasture without natural barriers are shown in Table 12 and Table 13.

*((Acres/Patches) *Cost/Acre)/4 = Cost/Side*
*Cost/Side*4 = Cost/Patch*
**Acreage and patch number based on (Limb et al 2011) cow-calf study*

Table 12. Firebreak Construction Annual Costs: PBG

| Firebreak Construction Annual Costs: Patch-Burning | | | |
|---|---|---|---|
| Acres | 150 | 25 Acres Burned Rotationally Each Year | |
| Patches | 6 | | |
| Cost/Acre | $ 1.77 | | |
| Cost/Side | $ 11.05 | | |
| **Patch 2: fall** | **Patch 1: spring** | **Year 1** | **$ 77.34** |
| **Burn 3 Sides** | **Burn 4 Sides** | | |
| **$ 33.15** | **$ 44.20** | | |
| **Patch 3: spring** | **Patch 4: fall** | **Year 2** | **$ 55.25** |
| **Burn 3 Sides** | **Burn 2 Sides** | | |
| **$ 33.15** | **$ 22.10** | | |
| **Patch 6: fall** | **Patch 5: spring** | **Year 3** | **$ 55.25** |
| **Burn 2 Sides** | **Burn 3 Sides** | | |
| **$ 22.10** | **$ 33.15** | | |
| **3 Year Investment Cost** | | | **$ 187.84** |

Table 13. Firebreak Construction Annual Costs: TB

| Firebreak Construction Annual Costs: Traditional | | | |
|---|---|---|---|
| Acres | 150 | 150 Acres Burned Every 3 Years | |
| Patches | 0 | | |
| Cost/Acre | $ 1.12 | | |
| Cost/Side | $ 42.08 | | |
| **1 Pasture** | | **Year 1** | **$ 168.33** |
| | | **Year 2** | **$ -** |
| | | **Year 3** | **$ -** |
| **3 Year Investment Cost** | | | **$ 168.33** |

Firebreak construction costs decrease by $22.09 in years two and three when using PBG to add up to a three-year investment cost of $187.84. Costs for TB over the course of three years result in an investment cost of $168.33. While firebreak costs for PBG are approximately $19 more than TB, the costs of building firebreaks is spread out over the cost of three years rather than all in one year. This provides potential benefits during a year where other input costs are higher.

A decrease in firebreak construction potentially results in a decrease in fuel costs. Since 77% of respondents utilized mowed lines as a way of building firebreaks, Table 14 and Table 15 are calculated based on producers utilizing equipment and fuel to mow down firebreaks in their pastures. The cost of equipment is not included in these calculations as this estimate is only for fuel costs.

Table 14. Annual Fuel Costs: PBG

| **Annual Fuel Costs: Patch-Burning** | | | |
|---|---|---|---|
| Acres | 150 | **25 Acres Burned Rotationally Each Year** | |
| Patches | 6 | | |
| Cost/Acre | $ 0.88 | | |
| Cost/Side | $ 5.50 | | |
| **Patch 2: fall** | **Patch 1: spring** | **Year 1** | **$ 38.47** |
| **Mow 3 Sides** | **Mow 4 Sides** | | |
| **$ 16.49** | **$ 21.98** | | |
| **Patch 3: spring** | **Patch 4: fall** | **Year 2** | **$ 27.48** |
| **Mow 3 Sides** | **Mow 2 Sides** | | |
| **$ 16.49** | **$ 10.99** | | |
| **Patch 6: fall** | **Patch 5: spring** | **Year 3** | **$ 27.48** |
| **Mow 2 Sides** | **Mow 3 Sides** | | |
| **$ 10.99** | **$ 16.49** | | |
| **3 Year Investment Cost** | | | **$ 93.43** |

Table 15. Annual Fuel Costs: TB

| Annual Fuel Costs: Traditional | | | |
|---|---|---|---|
| Acres | 150 | 150 Acres Burned Every 3 Years | |
| Patches | 0 | | |
| Cost/Acre | $ 0.29 | | |
| Cost/Side | $ 10.96 | | |
| 1 Pasture | | Year 1 | $ 43.82 |
| | | Year 2 | $ - |
| | | Year 3 | $ - |
| 3 Year Investment Cost | | | $ 43.82 |

Fuel costs for PBG decreased by $10.99 in years two and three, resulting in a three-year investment fuel cost of $93.43. The three-year investment fuel cost for TB was $43.82. The fuel cost difference between the two management practices is approximately $49 every three years. Labor costs are also expected to decrease due to firebreak construction reducing after year one. Firebreak construction and fuel costs both reduced by 28.5%, so the assumption made is that labor will also reduce by that amount. In year one, labor costs total to $1.37 per acre ($68.70/50 acres). Therefore, costs will decrease by $19.58 in years two and three. Burn costs for a three-year investment PBG and TB are compared and shown in Table 16.

Table 16. 3-Year Total Investment Costs for Burning using PBG and TB
[b]details in Appendix

| | Patch-Burning | Traditional Burning |
|---|---|---|
| **[b]3-Year Investment Cost** | $677.67 | $317.14 |
| **Difference** | $360.53 | |
| **Per Acre Difference** | $2.40 | |

Estimates convey that implementing and utilizing patch-burning will cost more than a traditional burn approach. However, the benefits provided by patch-burning and grazing potentially justify these higher implementation costs. For example, higher quality forages provide a higher nutrient intake and a lower supplemental feed requirement.

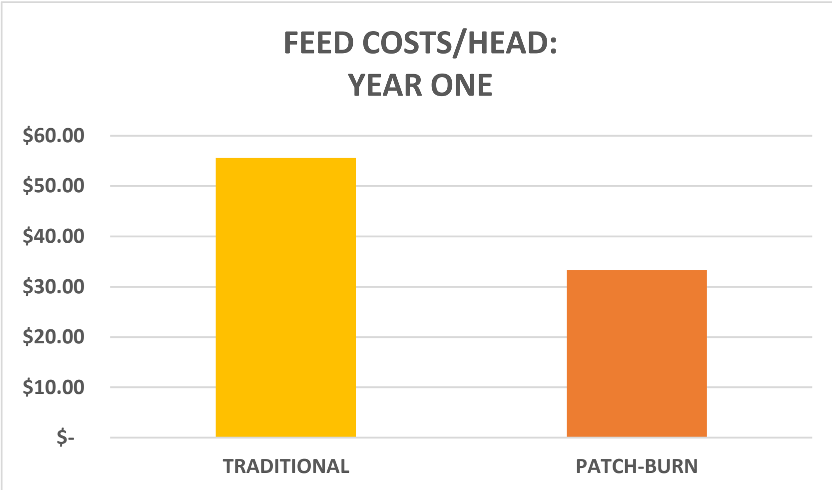
## **Feed Costs:**

In the Limb et al. 2011 study, animal performance was measured and compared for traditional burning and patch-burning using cow-calf pairs. Each pasture contained eight pairs that were placed on 150 acres under continuous grazing for four years (2003-2006). Patch-burned pastures were burned twice a year; one patch in the spring and one in the fall. Traditionally burned pastures were burned entirely every three years. As a result of accessible high-quality forages, patch-burning created an approximate annual savings of $20 per head in supplemental feed costs (Table 17). Cows on traditionally burned pastures were fed for 150 days (November 1-April 1). Cows on patch-burned pastures were fed for 90 days (January 1-April 1). Estimates are shown below (Figure 20) of supplemental feed costs for year one.

Table 17. Supplemental Feed Costs for PBG and TB
Estimates based on Limb et al. 2011 study and Lalman 2021 feed cost analysis

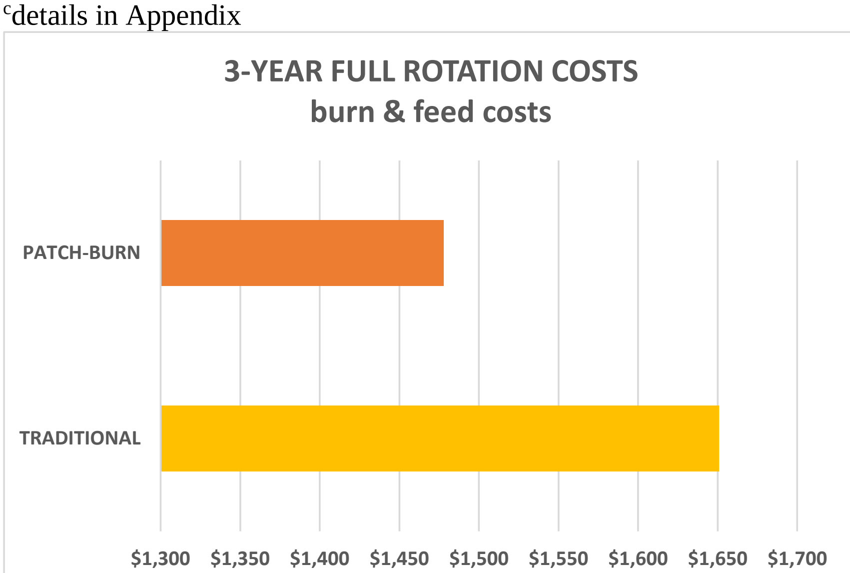
| | Number of Head | Days on Feed | $/head/day | Total | $/head/year |
|---|---|---|---|---|---|
| PBG | 8 | 90 | 0.37 | $266.76 | $33.35 |
| TB | 8 | 150 | 0.37 | $444.60 | $55.58 |

Figure 20. Supplemental Feed Costs for Eight Cows in Third Trimester of Pregnancy Grazing 150 Acres in Year One




Supplemental feed costs are expected to remain steady year after year if all else is held constant. After three years, allowing each practice to complete a full rotation of burns, burn costs and supplemental feed costs are 10% lower compared to costs when utilizing traditional burning (Figure 21). Consistent and continual access to high-quality forages through patch-burning and grazing each year allows cattle producers to reduce feed costs, justifying the higher cost of using patch-burning.

Figure 21. Total Burn and Feed Costs after 3-Year Burn Rotations for PBG and TB
Total Costs for Supplementing Eight Lactating Cows Grazing 150 Acres
[c]details in Appendix



However, input costs and weather conditions are volatile. A drought potentially results in increased feed costs or destocking due to limited forages. Patch-burning provides alleviation by reducing feed costs, but only if adequate rainfall is present to produce forage growth in recently burned patches. Fortunately, an additional benefit of patch-burning and grazing is potential mitigation of reduced forages from drought impacts. High quality forages may be slower in emerging in recently burned areas, but unburned and ungrazed areas provide a higher availably of forages for cattle to rely on. The severity and timing of a drought also affects burn schedules and the possibility of burning at all. Preparations are necessary to take full advantage of utilizing prescribed fire as a rangeland management tool.

**Drought Impact Mitigation:**

Calculating forage availability during a drought aids cattle producers in determining the amount of days cattle can rely on forage before requiring a supplement (Table 18). Patch-burning presents three burn options during drought: two patches (scenarios 1 & 3), one patch (scenarios 2 & 4), or not burn at all (scenario 5). Traditional burning presents two options: burn entire pasture (scenarios 1 & 2) or not burn at all (scenarios 3-5).

Table 18. Forage Availability during Drought in Stockpiled Patches
Number of Days Eight Lactating Cows can rely on Stockpiled Forage on 150 Acres
[d]details in Appendix

| Scenarios | Number of Days 8 Cow-Calf Pairs can rely on Stockpiled Forage |
|---|---|
| **1 & 3: Burning Two Patches** | 3.65 |
| **2 & 4: Burning One Patch** | 4.56 |
| **1 & 2: Burning Entire Pasture** | 0 |
| **3 – 5: Not Burning at All** | 5.47 |

Awareness of forage quantity allows for feed costs to be calculated for the four different burn options during a drought (Table 19). Feed requirements and costs provided were calculated using estimates and assumptions from literature (Lalman 2021; Lalman and Richards 2017). Estimates are for a 210-day period (April – October) during year one of the second rotation of burning for each option.

Spring calving cows will be lactating and nursing a calf during the months represented in Table 15. A 1,100-pound lactating cow requires about 29 pounds of dry matter intake (DMI) per day and 16.8 pounds of total digestible nutrients (TDN) per day. Lactating cows will consume 2.2% of their body weight when grazing low-quality forage (>52% TDN), providing 24.2 pounds of daily DMI and 14.5 pounds of daily TDN. Therefore, supplemental feed with hay may be required to maintain BCS through the drought. The assumption made for the scenarios is that the forage available contains at least 50% TDN, meaning any supplement provided needs to contain at least 50% TDN as well. The type of hay used for calculations is mixed grass – (good fair/trade) hay as the price of $170 per ton (OK Dept. of Ag Market News 2023). The supplemental feed used is a 25% protein supplement at $340 per ton. The amount of feed required during a drought has the potential to vary during a drought when utilizing patch-burning. Depending on the severity of the drought, high-quality forages may still emerge containing 59% TDN, meeting the nutrient requirement (Lalman and Richards 2017; Lalman 2021). Occasionally being able to graze these high-quality forages allows for cattle to obtain nutrients from the forage, reducing the cost of feeding a supplement for producers.

Table 19. Feed Costs based on Forage Availability during Drought
Total Costs for Supplementing Eight Lactating Cows Grazing 150 Acres During Drought
[e]details in Appendix

| Scenarios | Hay & Feed Costs |
|---|---|
| **1 & 3: Burning Two Patches** | $4,926.08 |
| **2 & 4: Burning One Patch** | $4,908.11 |
| **1 & 2: Burning Entire Pasture** | $4,998.00 |
| **3 – 5: Not Burning at All** | $4,890.13 |

Calculations convey that not burning at all results in the lowest feed costs during a drought by approximately $17 compared to burning a single patch in the spring. However, without fire, woody plant encroachment (WPE) will continue taking over pastures. Grazing rangelands overtaken with red cedar over time will result in limited forages, then resulting in destocking or increase feed costs. Therefore, patch-burning and grazing is potentially the best option for mitigating drought, reducing feed costs, and controlling WPE in comparison to burning an entire pasture every three years or not burning at all.

**6-Year Cost-Benefit Analysis:**

Figures 22-24[f] convey burn costs and feed costs after six years for different options of patch-burning and grazing (PBG) and traditional burning (TB). During the six years, year four represents a drought year where increased feed costs are accounted for. Additionally, one patch is burned during the drought year with two patches being burned in all other years. Costs associated with burning an entire pasture (Figure 22) every three years regardless of drought are 3.11% higher compared to patch-burning and grazing.

Figure 22. 6-Year Costs Comparison: Scenario 2
TB: burn entire pasture during drought, PBG: burn one patch during drought
Total Costs for Supplementing Eight Lactating Cows Grazing 150 Acres
[f]details in Appendix

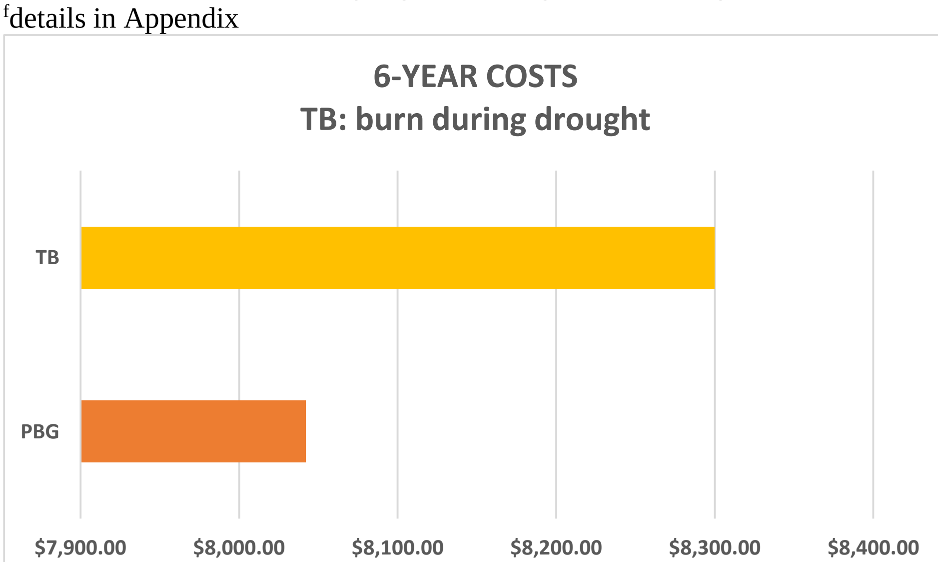


Figure 23 conveys that costs associated with not burning during the drought for traditionally burning are 1.83% higher than patch-burning and grazing. Cattle producers can potentially save an average of $25 per year in this scenario which is approximately $3 per cow per year.

Figure 23. 6-Year Cost Comparison: Scenario 4
TB: no burn during drought, PBG: burn one patch during drought
Total Costs for Supplementing Eight Lactating Cows Grazing 150 Acres
[f]details in Appendix

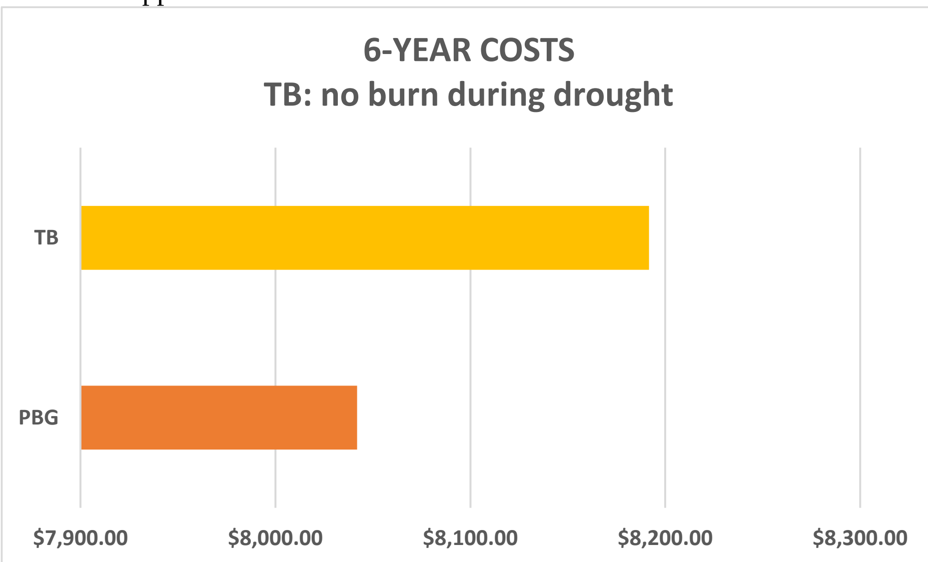
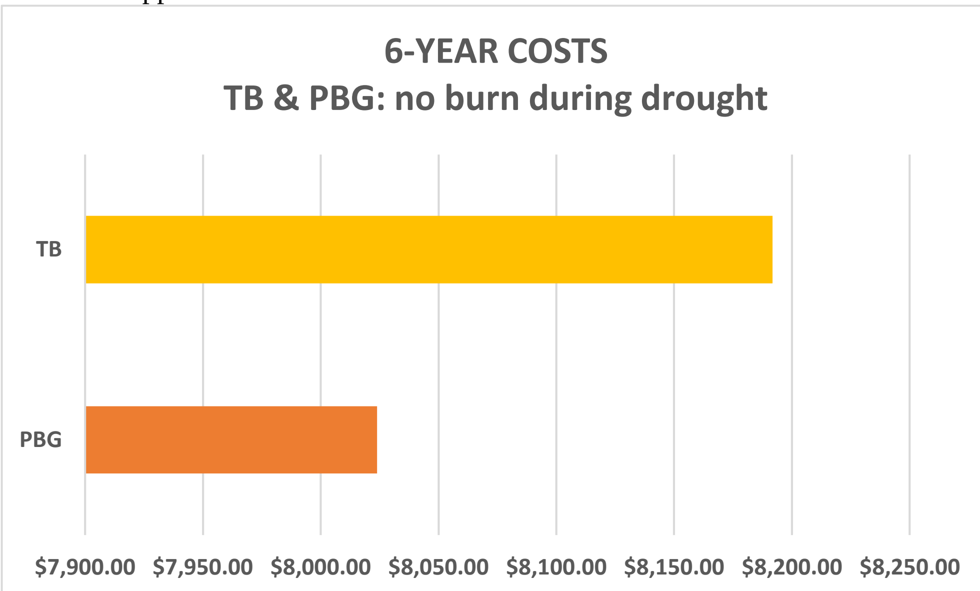



Figure 24 conveys an option that potentially offers the most savings in terms of burn costs and feed costs when not burning during a drought. Patch-burning allows for the option to skip a year of burning a patch during a drought. If it is not safe to burn, progress can be continued the next year when conditions improve. Practicing patch-burning and grazing provides flexibility while continually maintaining cattle production and reducing costs. Costs when deciding to skip a patch during a drought are 2.05% lower compared to not burning during a drought using a traditional approach. Producers can potentially save an average of $28 each year with this option which is approximately $3.50 per cow per year.

Figure 24. 6-Year Cost Comparison: Scenario 5
TB: no burn during drought, PBG: no burn during drought
Total Costs for Supplementing Eight Lactating Cows Grazing 150 Acres
[f]details in Appendix




Net present value (NPV) is calculated using the 2023 interest rate (4.83%) to compare the future value of the savings offered by patch-burning and grazing (PBG) compared to traditional burning (TB). Values are estimated after six years and include values with and without a drought year (Macrotrends 2023) (Table 20). Values show that skipping a year when using patch-burning and grazing offers the most savings of $113.48 per cow.

Table 20. NPV for 6-Year Future Savings per Cow
No Drought and Drought Scenarios 2, 4, & 5
[g]details in Appendix

| | **6-Year NPV: No Drought** | **6-Year NPV: Drought TB: Burn, PB: 1 Patch** | **6-Year NPV: Drought TB: No Burn, PB: 1 Patch** | **6-Year NPV: Drought No Burn for Either** |
|---|---|---|---|---|
| **PBG** | $135.46 | $212.26 | $93.72 | $113.48 |
| **TB** | $0.00 | -$98.78 | $19.76 | $0.00 |

From 2009-2015, the interest rate varied from between 0.09% and 0.18% (Macrotrends 2023). Future savings values are calculated in Table 21 to represent the savings patch-burning and grazing could have potentially offered before, during, and after the drought (2009-2014). Similar to Table 20, if cow-calf producers had utilized patch-burning and grazing prior to and after the 2011 drought and skipping a year in 2011, they could have taken advantage of saving $100.34 per cow.

Table 21. NPV for Potential 6-Year Savings per Cow using PBG in 2011 Drought
[h]details in Appendix

| | **6-Year NPV: Drought TB: Burn, PB: 1 Patch** | **6-Year NPV: Drought TB: No Burn, PB: 1 Patch** | **6-Year NPV: Drought No Burn for Either** |
|---|---|---|---|
| **PBG** | $190.46 | $82.31 | $100.34 |
| **TB** | -$90.12 | $18.03 | $0.00 |

Burn costs, feed costs, weather, and forage productivity are all considerable factors when Oklahoma cow-calf producers are contemplating making a change in rangeland management involving fire. Therefore, results providing cost minimizing options to best manage grazing rangelands aids in the decision-making process. Cattle production in Oklahoma consists heavily of cow-calf producers that the U.S. beef industry relies on to supply beef to meet consumer demand. Managing rangelands by utilizing patch-burning and grazing is a potential practice that raises cattle in a profitable way while maintaining and preserving the environment.

# CHAPTER V

## CONCLUSION

Cattle production is a complex industry that involves making profitable decisions in an ever-changing market. Inflation of inputs, cattle prices, and weather conditions are all influential factors that affect cattle producers in Oklahoma and across the United States. Efficient and effective rangeland management practices represent one necessary tool that can be implemented to potentially combat the unexpected circumstances producers must face year after year. Patch-burning and grazing (PBG) is a rangeland management tool that allows cattle producers to maintain and restore rangelands while also reducing costs to raise their cattle.

Grazing is the predominant use of rangelands in Oklahoma. Cow-calf operations in Oklahoma rely heavily on rangelands to graze cattle to support a state-wide $3.5 billion cattle industry. Oklahoma rangelands consist of several different soil and vegetation types, providing a variety of forages across the state. Forage production is vital to cows who graze year-round to maintain an acceptable BCS to raise a calf every year. Limited forage because of WPE and drought results in cattle producers having to destock or provide supplements, both of which negatively affect net income. Managing rangelands with prescribed fire, specifically through PBG, is a preventative management practice that limits WPE and creates mitigation during drought.

Many landowners are skeptical of utilizing any form of prescribed fire as a management tool due to fear and liability of wildfire. As a result of fire suppression, the natural development of rangelands has been disturbed, ultimately limiting range productivity over the years. The sustainability of rangelands will continue to be hindered by woody plant encroachment (WPE) if the adoption of fire management practices does not increase. The use of PBG is a fire management tool that improves and maintains sustainable rangelands while offering several benefits for cattle production.

Benefits of burning a single section of a pasture each year include improved range productivity, woody species control, and forage stockpiles. Limited research supporting the economics of PBG is one reason why producers may be skeptical of implementing a more conservation-based rangeland management approach. A cost-benefit analysis comparing PBG to traditional burning (TB) (burning an entire pasture every three years) provides economic information to aid cattle producers in making feasible and potentially more profitable decisions for their operations. An economic analysis further supports and emphasizes the positive outcomes offered by PBG on Oklahoma rangelands used for cow-calf production.

Results from the cost-benefit analysis of PBG in comparison to TB convey that PBG reduces feed costs for cattle producers when considered as a long-term investment and risk management practice. Burning two patches a year provides continual access to high-quality forages for cattle. Access to high-quality forages in early fall months due to burning a second patch allows for cattle to rely on forage rather than a supplemental feed for a longer period. This results in a reduction of winter feed costs by approximately $20 per head per year, all else remaining constant. When compared to TB, total burn costs and feed costs are 10% lower when using PBG after a full three-year burn rotation for both practices. The future value of these savings, based on the current interest rate, after six years (two full burn rotations) is just over $130 per cow, based on the optimal stocking rate of eight cow-calf pairs continuously grazing 150 acres (Limb et al. 2011).

During a drought year, cattle producers are presented with several options when using either burn practice. Utilizing PBG before and after the drought while deciding to skip burning any patches during a drought year potentially shows to be the most economical option. Cattle can rely on stockpiled forage for an additional five days before producers must provide hay and a supplement to meet nutritional requirements. This reduces supplemental costs by approximately $100 compared to burning the entire pasture during the drought year. Compared to burning a single patch during the drought years, skipping a year reduces costs by approximately $17. Over a period of six years with year four representing a drought year, not burning during a drought year when using PBG also shows to be the most cost effective when considering long-term feed costs and the annual cost of burning. The future values of these savings over six years are approximately $100 per cow. Burning two patches a year before and after the drought year reduces winter feed costs, providing an average savings of $3.50 per cow per year over the course of six years, all else remaining constant. These costs and savings only reflect the cost of burning and supplemental feeding. Losses from destocking and costs of rebuilding are not reflected in the cost-benefit analysis.

The cattle industry is continually growing and improving to feed an increasing population with less land and fewer resources. Patch-burning and grazing provides an alternative method of managing rangelands to be more sustainable and productive in the long run by limiting woody plant encroachment, mitigating drought impacts, and providing high-quality forages for cattle. Constructing a cost-benefit analysis allows cattle producers to decide whether they are willing to invest in patch-burning and grazing based on calculating long-term savings specific to their operations. An economic analysis of patch-burning and grazing provides a guide to answering one of the complicated and intertwined decisions Oklahoma cattle producers must make to maintain profitability, the environment, and the beef industry.

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# APPENDICES

[a]Table 22. Making the Decision between PBG and TB: Year One of First Rotation

| Year | DSCI | Rainfall (sum inches) | Category | average lbs/acre/year | acres | patches | lbs of forage/patch | patches burned annually | stockpiled acres | **available lbs of high quality forage in burned patches/year | available lbs of forage in stockpiled patches/year |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2003 | 42.2692 | 26.5 | normal | 4013 | 150 | 6 | 100325 | 2 | 100 | 200650 | 401300 |
| 2004 | 3.4423 | 37.33 | favorable | 5222 | 150 | 6 | 130550 | 2 | 100 | 261100 | 522200 |
| 2005 | 45.0385 | 30.31 | normal | 4013 | 150 | 6 | 100325 | 2 | 100 | 200650 | 401300 |
| 2006 | 272.6923 | 25.98 | unfavorable | 2577 | 150 | 6 | 64425 | 2 | 100 | 128850 | 257700 |
| 2003 | 42.2692 | 26.5 | normal | 4013 | 150 | 6 | 100325 | 1 | 125 | 100325 | 501625 |
| 2004 | 3.4423 | 37.33 | favorable | 5222 | 150 | 6 | 130550 | 1 | 125 | 130550 | 652750 |
| 2005 | 45.0385 | 30.31 | normal | 4013 | 150 | 6 | 100325 | 1 | 125 | 100325 | 501625 |
| 2006 | 272.6923 | 25.98 | unfavorable | 2577 | 150 | 6 | 64425 | 1 | 125 | 64425 | 322125 |
| 2003 | 42.2692 | 26.5 | normal | 4013 | 150 | 6 | 100325 | 0 | 150 | 0 | 601950 |
| 2004 | 3.4423 | 37.33 | favorable | 5222 | 150 | 6 | 130550 | 0 | 150 | 0 | 783300 |
| 2005 | 45.0385 | 30.31 | normal | 4013 | 150 | 6 | 100325 | 0 | 150 | 0 | 601950 |
| 2006 | 272.6923 | 25.98 | unfavorable | 2577 | 150 | 6 | 64425 | 0 | 150 | 0 | 386550 |

| Year | DSCI | Rainfall (sum inches) | Category | average lbs/acre/year | acres | acres burned every 3 years | stockpiled acres | **available lbs of high quality forage in burned patches/year | available lbs of forage in stockpiled patches/year |
|---|---|---|---|---|---|---|---|---|---|
| 2003 | 42.2692 | 26.5 | normal | 4013 | 150 | 150 | 0 | 601950 | 0 |
| 2004 | 3.4423 | 37.33 | favorable | 5222 | 150 | 150 | 0 | 783300 | 0 |
| 2005 | 45.0385 | 30.31 | normal | 4013 | 150 | 150 | 0 | 601950 | 0 |
| 2006 | 272.6923 | 25.98 | unfavorable | 2577 | 150 | 150 | 0 | 386550 | 0 |
| 2003 | 42.2692 | 26.5 | normal | 4013 | 150 | 0 | 150 | 0 | 601950 |
| 2004 | 3.4423 | 37.33 | favorable | 5222 | 150 | 0 | 150 | 0 | 783300 |
| 2005 | 45.0385 | 30.31 | normal | 4013 | 150 | 0 | 150 | 0 | 601950 |
| 2006 | 272.6923 | 25.98 | unfavorable | 2577 | 150 | 0 | 150 | 0 | 386550 |

**forage quality remains at its highest up to 150 days after burning and then begins to decline

[b]Table 23. 3-Year Annual Burn Cost Breakdown: Patch-Burning

| 3-Year Burn Costs Breakdown: Patch-Burning | | | |
|---|---|---|---|
| 150 Acres, 6 Patches, 25 Acres/Patch | | | |
| **Costs** | **Year 1** | **Year 2** | **Year 3** |
| | **$ breakdown** | **$ breakdown** | **$ breakdown** |
| Firebreak Construction | $ 77.34 | $ 55.25 | $ 55.25 |
| Labor | $ 68.70 | $ 49.12 | $ 49.12 |
| Fuel | $ 38.47 | $ 27.48 | $ 27.48 |
| Contractor | $ - | $ - | $ - |
| PBA Dues | $ 12.37 | $ 12.37 | $ 12.37 |
| Other | $ 64.12 | $ 64.12 | $ 64.12 |
| **Total Cost** | **$ 261.00** | **$ 208.33** | **$ 208.33** |
| **Total Cost/Acre** | **$ 5.22** | **$ 4.17** | **$ 4.17** |
| **Total 3-Year Investment** | | | **$ 677.67** |

[b]Table 24. 3-Year Annual Burn Cost Breakdown: Patch-Burning

| 3-Year Burn Costs Breakdown: Traditional | | | |
|---|---|---|---|
| 150 Acres | | | |
| **Costs** | **Year 1** | **Year 2** | **Year 3** |
| | **$ breakdown** | **$ breakdown** | **$ breakdown** |
| Firebreak Construction | $ 168.33 | $ - | $ - |
| Labor | $ 51.37 | $ - | $ - |
| Fuel | $ 43.82 | $ - | $ - |
| Contractor | $ - | $ - | $ - |
| PBA Dues | $ 23.76 | $ - | $ - |
| Other | $ 29.87 | $ - | $ - |
| **Total Cost** | **$ 317.14** | **$ -** | **$ -** |
| **Total Cost/Acre** | **$ 2.11** | **$ -** | **$ -** |
| **Total 3-Year Investment** | | | **$ 317.14** |

[c]Table 25. Burn and Feed Costs after 3 Years: Patch-Burning and Grazing

| **Patch-Burning & Grazing** | | | |
|---|---|---|---|
| | Year 1 | Year 2 | Year 3 |
| Burn Costs | $261.00 | $208.33 | $208.33 |
| Feed Costs | $266.76 | $266.76 | $266.76 |
| Total Cost | $527.76 | $475.09 | $475.09 |
| Cost/Acre | $3.52 | $3.17 | $3.17 |
| 3 Year Total Cost | **$1,477.94** | | |

[c]Table 26. Burn and Feed Costs after 3 Years: Traditional Burning

| **Traditional Burning** | | | |
|---|---|---|---|
| | Year 1 | Year 2 | Year 3 |
| Burn Costs | $317.00 | $0.00 | $0.00 |
| Feed Costs | $444.60 | $444.60 | $444.60 |
| Total Cost | $761.60 | $444.60 | $444.60 |
| Cost/Acre | $5.08 | $2.96 | $2.96 |
| 3 Year Total Cost | **$1,650.80** | | |

[d]Table 27. Days Cattle can Rely on Stockpiled Forage

| | Year | Category | available lbs of forage in stockpiled patches/year | available lbs of forage in stockpiled patches/day | *DMI of a 1,100 lb lactating cow on low quality forage (lbs/day) | number of days 8 cow-calf pairs are able to rely on stockpiled forage |
|---|---|---|---|---|---|---|
| **1** | 2006 | unfavorable | 257700 | 706.03 | 24.2 | **3.65** |
| **burning 2 patches each year** | | | | **requirement** | 29 | |
| | | | | ***DMI need** | 4.8 | |
| | | | | ***TDN need** | 2.3 | |
| **2** | 2006 | unfavorable | 322125 | 882.53 | 24.2 | **4.56** |
| **burning 1 patch each year** | | | | **requirement** | 29 | |
| | | | | ***DMI need** | 4.8 | |
| | | | | ***TDN need** | 2.3 | |

| | Year | Category | available lbs of forage in stockpiled patches/year | available lbs of forage in stockpiled patches/day | *DMI of a 1,100 lb lactating cow on low quality forage (lbs/day) | number of days 8 cow-calf pairs are able to rely on stockpiled forage |
|---|---|---|---|---|---|---|
| **1** | 2006 | unfavorable | 0 | 0 | 0 | **0.00** |
| **burn entire pasture** | | | | **requirement** | 29 | |
| | | | | ***DMI need** | 29 | |
| | | | | ***TDN need** | 16.8 | |
| **5** | 2006 | unfavorable | 386550 | 1059.04 | 24.2 | **5.47** |
| **not burning at all** | | | | **requirement** | 29 | |
| | | | | ***DMI need** | 4.8 | |
| | | | | ***TDN need** | 2.3 | |

[e]Table 28. Feed Requirements and Costs

| Option 1: burning 2 patches each year | | | | | | | **$ 4,926.08** |
|---|---|---|---|---|---|---|---|
| **Requirements** | | | **Supplied by Forage** | | **Supplemental Need** | | |
| **DMI (lbs/day)** | | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | |
| 29 | | 16.8 | 24.2 | 14.5 | 4.8 | 2.3 | |
| *feed hay containing 50% TDN & 25% protien supplement will meet the needs of lactating cows* | | | | | | | |
| **Amount to feed** | | **$/lb** | | **$/hd** | **Head** | **Days Fed** | **Total Cost** |
| Hay | Feed | Hay | Feed | Hay & Feed | | | |
| 0 | 3 | $ - | $ 0.17 | $ 0.51 | 8 | 3.65 | $ 14.88 |
| 29 | 3 | $ 0.09 | $ 0.17 | $ 2.98 | 8 | 206.35 | $ 4,911.21 |

| Option 2: burning 1 patch each year | | | | | | | **$ 4,908.11** |
|---|---|---|---|---|---|---|---|
| **Requirements** | | | **Supplied by Forage** | | **Supplemental Need** | | |
| **DMI (lbs/day)** | | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | |
| 29 | | 16.8 | 24.2 | 14.5 | 4.8 | 2.3 | |
| *feed hay containing 50% TDN & 25% protien supplement will meet the needs of lactating cows* | | | | | | | |
| **Amount to feed** | | **$/lb** | | **$/hd** | **Head** | **Days Fed** | **Total Cost** |
| Hay | Feed | Hay | Feed | Hay & Feed | | | |
| 0 | 3 | $ - | $ 0.17 | $ 0.51 | 8 | 4.56 | $ 18.60 |
| 29 | 3 | $ 0.09 | $ 0.17 | $ 2.98 | 8 | 205.44 | $ 4,889.51 |

| Option 3: burning entire pasture | | | | | | | **$ 4,998.00** |
|---|---|---|---|---|---|---|---|
| **Requirements** | | | **Supplied by Forage** | | **Supplemental Need** | | |
| **DMI (lbs/day)** | | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | |
| 29 | | 16.8 | 0 | 0 | 29 | 16.8 | |
| *feed hay containing 50% TDN & 25% protien supplement will meet the needs of lactating cows* | | | | | | | |
| **Amount to feed (lbs/day)** | | **$/lb** | | **$/hd** | **Head** | **Days Fed** | **Total Cost** |
| Hay | Feed | Hay | Feed | Hay & Feed | | | |
| 29 | 3 | $ 0.09 | $ 0.17 | $ 2.98 | 8 | 210 | $ 4,998.00 |
| | | | | | | | |

| Option 4: not burning at all | | | | | | | **$ 4,890.13** |
|---|---|---|---|---|---|---|---|
| **Requirements** | | | **Supplied by Forage** | | **Supplemental Need** | | |
| **DMI (lbs/day)** | | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | **DMI (lbs/day)** | **TDN (lbs/day)** | |
| 29 | | 16.8 | 24.2 | 14.5 | 4.8 | 2.3 | |
| *feed hay containing 50% TDN & 25% protien supplement will meet the needs of lactating cows* | | | | | | | |
| **Amount to feed (lbs/day)** | | **$/lb** | | **$/hd** | **Head** | **Days Fed** | **Total Cost** |
| Hay | Feed | Hay | Feed | Hay & Feed | | | |
| 0 | 3 | $ - | $ 0.17 | $ 0.51 | 8 | 5.47 | $ 22.32 |
| 29 | 3 | $ 0.09 | $ 0.17 | $ 2.98 | 8 | 204.53 | $ 4,867.81 |

[f]Table 29. Burn and Feed Costs for Each Scenario After Drought Year

| Patch-Burning & Grazing: One Patch in Drought Year | | | |
|---|---|---|---|
| | Year 4 | Year 5 | Year 6 |
| Burn Costs | $261.00 | $208.33 | $208.33 |
| Feed Costs:Winter | $444.60 | $266.76 | $266.76 |
| Feed Costs:Summer Drought | $4,908.11 | $0.00 | $0.00 |
| Total Cost | $5,613.71 | $475.09 | $475.09 |
| Cost/Acre | $37.42 | $3.17 | $3.17 |
| 3 Year Total Cost | **$6,563.89** | | |
| **Patch-Burning & Grazing: Not Burning in Drought Year** | | | |
| | Year 4 | Year 5 | Year 6 |
| Burn Costs | $261.00 | $208.33 | $208.33 |
| Feed Costs:Winter | $444.60 | $266.76 | $266.76 |
| Feed Costs:Summer Drought | $4,890.13 | $0.00 | $0.00 |
| Total Cost | $5,595.73 | $475.09 | $475.09 |
| Cost/Acre | $37.30 | $3.17 | $3.17 |
| 3 Year Total Cost | **$6,545.91** | | |
| **Traditional Burning: Burn Entire Pasture in Drought Year** | | | |
| | Year 4 | Year 5 | Year 6 |
| Burn Costs | $317.00 | $0.00 | $0.00 |
| Feed Costs:Winter | $444.60 | $444.60 | $444.60 |
| Feed Costs:Summer Drought | $4,998.00 | $0.00 | $0.00 |
| Total Cost | $5,759.60 | $444.60 | $444.60 |
| Cost/Acre | $38.40 | $2.96 | $2.96 |
| 3 Year Total Cost | **$6,648.80** | | |
| **Traditional Burning: Not Burning during Drought** | | | |
| | Year 4 | Year 5 | Year 6 |
| Burn Costs | $317.00 | $0.00 | $0.00 |
| Feed Costs:Winter | $444.60 | $444.60 | $444.60 |
| Feed Costs:Summer Drought | $4,890.13 | $0.00 | $0.00 |
| Total Cost | $5,651.73 | $444.60 | $444.60 |
| Cost/Acre | $37.68 | $2.96 | $2.96 |
| 3 Year Total Cost | **$6,540.93** | | |

*all calculations include a drought year in year 4

[g]Table 30. Net Present Values of Patch-Burning and Grazing: 2023 interest rate

| | | | | | | |
|---|---|---|---|---|---|---|
| PBG: 2023 interest rate | | | | | | |
| Future Value of Uniform Series | | | | | | |
| | 6-Year Savings: No Drought in Year 4 | | | | | |
| | savings | $20 | | | | |
| | years | 6 | | | | |
| | interest rate | 4.83% | | | | |
| | **NPV** | **$135.46** | | | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $20.00 | 4.83% | $25.32 | | |
| | 2 | $20.00 | | $24.15 | | |
| | 3 | $20.00 | | $23.04 | | |
| | 4 | $89.89 | | $98.78 | | |
| | 5 | $20.00 | | $20.97 | | |
| | 6 | $20.00 | | $20.00 | | |
| **total** | | | | **$212.26** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: no burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $20.00 | 4.83% | $25.32 | | |
| | 2 | $20.00 | | $24.15 | | |
| | 3 | $20.00 | | $23.04 | | |
| | 4 | -$17.98 | | -$19.76 | | |
| | 5 | $20.00 | | $20.97 | | |
| | 6 | $20.00 | | $20.00 | | |
| **total** | | | | **$93.72** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; No Burn for Either Practice | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $20.00 | 4.83% | $25.32 | | |
| | 2 | $20.00 | | $24.15 | | |
| | 3 | $20.00 | | $23.04 | | |
| | 4 | $0.00 | | $0.00 | | |
| | 5 | $20.00 | | $20.97 | | |
| | 6 | $20.00 | | $20.00 | | |
| **total** | | | | **$113.48** | | |

[g]Table 31. Net Present Values of Traditional Burning: 2023 interest rate

| | | | | | | |
|---|---|---|---|---|---|---|
| TB: 2023 interest rate | | | | | | |
| Future Value of Uniform Series | | | | | | |
| | 6-Year Savings: No Drought in Year 4 | | | | | |
| | savings | $0 | | | | |
| | years | 6 | | | | |
| | interest ra | 4.83% | | | | |
| | **NPV** | **$0.00** | | | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $0.00 | 4.83% | $0.00 | | |
| | 2 | $0.00 | | $0.00 | | |
| | 3 | $0.00 | | $0.00 | | |
| | 4 | -$89.89 | | -$98.78 | | |
| | 5 | $0.00 | | $0.00 | | |
| | 6 | $0.00 | | $0.00 | | |
| **total** | | | | **-$98.78** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: no burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $0.00 | 4.83% | $0.00 | | |
| | 2 | $0.00 | | $0.00 | | |
| | 3 | $0.00 | | $0.00 | | |
| | 4 | $17.98 | | $19.76 | | |
| | 5 | $0.00 | | $0.00 | | |
| | 6 | $0.00 | | $0.00 | | |
| **total** | | | | **$19.76** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; No Burn for Either Practice | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $0.00 | 4.83% | $0.00 | | |
| | 2 | $0.00 | | $0.00 | | |
| | 3 | $0.00 | | $0.00 | | |
| | 4 | $0.00 | | $0.00 | | |
| | 5 | $0.00 | | $0.00 | | |
| | 6 | $0.00 | | $0.00 | | |
| **total** | | | | **$0.00** | | |

[a]a

[h]Table 32. Net Present Values of Patch-Burning and Grazing during 2011 Drought

| | | | | | | |
|---|---|---|---|---|---|---|
| PBG: avg. interest rate (2009-2015) | | | | | | |
| | 2009 | 0.16% | | | | |
| | 2010 | 0.18% | | | | |
| | 2011 | 0.10% | | | | |
| | 2012 | 0.14% | **0.13%** | | | |
| | 2013 | 0.11% | | | | |
| | 2014 | 0.09% | | | | |
| | 2015 | 0.13% | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $20.00 | 0.13% | $20.13 | | |
| | 2 | $20.00 | | $20.10 | | |
| | 3 | $20.00 | | $20.08 | | |
| | 4 | $89.89 | | $90.12 | | |
| | 5 | $20.00 | | $20.03 | | |
| | 6 | $20.00 | | $20.00 | | |
| **total** | | | | **$190.46** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: no burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $20.00 | 0.13% | $20.13 | | |
| | 2 | $20.00 | | $20.10 | | |
| | 3 | $20.00 | | $20.08 | | |
| | 4 | -$17.98 | | -$18.03 | | |
| | 5 | $20.00 | | $20.03 | | |
| | 6 | $20.00 | | $20.00 | | |
| **total** | | | | **$82.31** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; No Burn for Either Practice | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $20.00 | 0.13% | $20.13 | | |
| | 2 | $20.00 | | $20.10 | | |
| | 3 | $20.00 | | $20.08 | | |
| | 4 | $0.00 | | $0.00 | | |
| | 5 | $20.00 | | $20.03 | | |
| | 6 | $20.00 | | $20.00 | | |
| **total** | | | | **$100.34** | | |

[h]Table 33. Net Present Values of Traditional Burning during 2011 Drought

| | | | | | | |
|---|---|---|---|---|---|---|
| TB: avg. interest rate (2009-2015) | | | | | | |
| | 2009 | 0.16% | | | | |
| | 2010 | 0.18% | | | | |
| | 2011 | 0.10% | | | | |
| | 2012 | 0.14% | **0.13%** | | | |
| | 2013 | 0.11% | | | | |
| | 2014 | 0.09% | | | | |
| | 2015 | 0.13% | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $0.00 | 0.13% | $0.00 | | |
| | 2 | $0.00 | | $0.00 | | |
| | 3 | $0.00 | | $0.00 | | |
| | 4 | -$89.89 | | -$90.12 | | |
| | 5 | $0.00 | | $0.00 | | |
| | 6 | $0.00 | | $0.00 | | |
| **total** | | | | **-$90.12** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; TB: no burn, PBG: 1 Patch | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $0.00 | 0.13% | $0.00 | | |
| | 2 | $0.00 | | $0.00 | | |
| | 3 | $0.00 | | $0.00 | | |
| | 4 | $17.98 | | $18.03 | | |
| | 5 | $0.00 | | $0.00 | | |
| | 6 | $0.00 | | $0.00 | | |
| **total** | | | | **$18.03** | | |
| | | | | | | |
| Future Value of Non-Uniform Series | | | | | | |
| 6-Year Savings: Drought in Year 4; No Burn for Either Practice | | | | | | |
| | years | savings/year | interest rate | **NPV** | | |
| | 1 | $0.00 | 0.13% | $0.00 | | |
| | 2 | $0.00 | | $0.00 | | |
| | 3 | $0.00 | | $0.00 | | |
| | 4 | $0.00 | | $0.00 | | |
| | 5 | $0.00 | | $0.00 | | |
| | 6 | $0.00 | | $0.00 | | |
| **total** | | | | **$0.00** | | |

# VITA

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