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Abstract

The recently implemented Rainfall Index Annual Forage pilot program aims to provide risk coverage for annual forage producers in select states through the use of area rainfall indices as a proxy for yield. This paper utilizes unique data from a long-term study of annual ryegrass production with rainfall recorded at the site to determine whether or not the use of rainfall indices provides adequate coverage for annual forage growers. The rainfall index is highly correlated with actual rainfall. However, it does not provide much yield loss risk protection for our specific data.

Keywords: *rainfall index, forage policy, annual forage, risk management*

Introduction

The United States Department of Agriculture (USDA) and the Risk Management Agency (RMA) established the Rainfall Index Annual Forage Program (RIAFP) in May of 2013 with the goal of providing risk coverage for annual forage producers in the United States (USDA, RMA 2013). Similar to the previously established Pasture, Rangeland, and Forage insurance program, this insurance product aims to offer catastrophic risk protection and buy-up coverage to a group of previously underserved producers (Campiche and Jones 2013). Initially being tested as a pilot program in Texas, Oklahoma, Kansas, Nebraska, South Dakota, and North Dakota, this program covers annually planted crops that are used for livestock feed or fodder including grasses and mixed forages (ryegrass, sudan, etc), and small grains (wheat, oats, etc.) among others (Campiche and Jones 2013). As a new and relatively little known program, there is a need to determine if the design of this program provides the intended risk protection. The objective of this paper is to measure the effectiveness of the RIAFP as a risk management tool for forage producers and to attempt to guide producers as to which rainfall index intervals to choose.

Because actual forage production is often difficult to measure and regulate, indemnity qualification for the program is based on interpolated precipitation within a producer's respective area or grid. This distinction is made under the assumption that forage yields are closely correlated with precipitation and attempts to avoid the moral hazard and adverse selection that farm-level yield insurance would introduce through allowing producers to self-report yield information. However, reducing the potential of moral hazard though the use of a variable other than actual yield could lead to a decrease in the level of risk protection provided (Nadolnyak and Vedenov 2013; Glauber 2004). Crop insurance programs based on a rainfall index were first implemented in 2007 with a pilot program for the now permanent Pasture, Rangeland, and Forage insurance program. The Pasture, Rangeland, and Forage program has since been joined by the Apiculture insurance program and the RIAFP. Each of these programs utilize rainfall indices calculated from weather data collected by the National Oceanic and Atmospheric Administration (NOAA).

The RMA rainfall indices are based on weather data collected by NOAA and are designed to insure against declines in an index in each 0.25° latitude by 0.25° longitude grid (Shields 2013; USDA, RMA 2014). Since there are more grids than weather data collection stations, a weighted average is calculated using the nearest four stations. The question of concern is does actual forage production follow the RMA rainfall indices closely enough to protect producers from production risk?

Relatively little work has analyzed the use of the aforementioned rainfall indices in a crop insurance framework. Brooks et al. (2014) and Vandeveer, Berger, and Stockton (2013) discussed the usefulness and implementation of rainfall index based crop insurance programs for forage and livestock production in the United States. Maldonado (2011) analyzed the coverage level choice producers face under a rainfall index based crop insurance program and provides an in-depth overview of the rainfall index used in the RIAFP. From a different perspective, Nadolnyak and Vedenov (2013) examined whether a seasonal rainfall index or El Nino index are better predictors of forage yield in the Southeastern United States. They find that a higher correlation between the rainfall index and yield improves the efficiency of the insurance product and that it is possible for adverse selection to exist if the rainfall index is highly correlated with long run weather forecasts. Breustedt, Bokusheva, and Heidelbach (2008) found that a weather index measure provided less risk reduction than a regional yield index for wheat producers in Kazakhstan.

The first purpose of this paper is to determine whether or not the use of rainfall indices provides the intended production risk coverage for annual forage growers. We analyze annual ryegrass production at the Samuel Roberts Noble Foundation Red River Farm in Burneyville, OK from 1974 to 2008. The data used include actual forage production over this time period at the same location as a weather station which has collected actual rainfall data since 1993. This is a relatively long series of data for continuous agronomic research and allows many years for which to consider the effectiveness of the design of the RIAFP. To measure how well actual forage production follows the NOAA rainfall indices, we calculate the correlations between actual forage production, the rainfall index, and actual rainfall. Further, we estimate a linear model including other variables that might impact forage yield. We also perform ex-post analyses of how often the RIAFP would have triggered an indemnity payment for the acreage in the dataset as well as what the total payoffs would have been relative to the premiums paid.

Expected implications surround the applicability of establishing this pilot program as a permanent and nationwide program. If forage yields show little correlation with the rainfall index, then there could be a need to redesign the insurance product to provide greater risk protection. Even if ineffective in reducing risk, the program can be viewed as a way of transferring income to a sector of agricultural producers generally underserved by subsidized risk products relative to other crops. Because this is a relatively little known program, this information could be useful for policy makers as well as to those in extension who may be asked about this program by growers.

Program Description

The RIAFP offers coverage to producers who annually plant crops used for livestock feed or fodder such as grazing, haying, haying/grazing, silage, and green chopping among others (USDA, FDIC, RMA 2015). Catastrophic risk (CAT) coverage is available for all of the above uses except for grazing while buy-up coverage is available for any of the mentioned uses. The forage insurance program relies on a rainfall index that is calculated using weather precipitation data collected by the NOAA and is designed to insure against declines in the index in each 0.25° latitude by 0.25° longitude grid compared to the historical average. Premiums for CAT are subsidized 100 percent by USDA. Additionally, producers have the option to purchase subsidized buy-up coverage for which they are required to pay only a portion of the premium.

The RIAFP is similar to other insurance programs in that a producer makes a series of choices that influence the premium cost and coverage level for his operation (USDA, FDIC, RMA 2013). First, the producer chooses the growing season and possible rainfall indices by choosing a planting date. Crops planted July 15 through December 15 are eligible for growing season one which has available rainfall index intervals from September through March. Growing Season two provides coverage for crops planted December 15 through July 15 with available rainfall index intervals from March through September. The producer can double crop and receive indemnities for two growing seasons within the same year if he can prove he has double cropped for the past two years.

Growing season is the only choice made for CAT coverage. The coverage level is set by the RMA at 65 percent of the historical average rainfall level over the entire September to March interval and the productivity factor is set at 45 percent of the county base acre value set by the RMA. The premiums for CAT coverage are fully subsidized by USDA though there is a $300 sign-up fee (USDA, FDIC, RMA 2015).

Buy-up coverage offers the producer much more flexibility in designing a desired insurance product. Beyond growing season, producer next chooses the coverage level (trigger index level) to insure in the same units as the rainfall index. The expected rainfall index which is calculated from historical data is adjusted so that the baseline for each year is 100 (USDA, FDIC, RMA 2013). Thus, the producer selects a coverage level ranging from 70 to 100 percent (USDA, FDIC, RMA 2015). For example, if the producer chooses a 90 percent coverage level, an indemnity will only be triggered if the actual rainfall index is less than 90.

Next, a producer wishing to purchase buy-up coverage must choose the value per acre of his forage production. This is accomplished by choosing a productivity factor to adjust the producer's respective county base value which is provided by the RMA for each county within the participating states. This productivity factor can range from 60 to 150 in one percent increments where a choice of 100 would indicate that the producer believes the value of an acre of his forage production is equal to the county base.

The final choice the producer must make is which rainfall indices to use in terms of months and the percent of value to allocate to these indices. The rainfall index is calculated over a period of two months with specific intervals available for each growing season. Each two month interval between September and March is available for growing season one while intervals within March to September are available in growing season two (USDA, FDIC, RMA 2013). The producer must select three intervals within the time period for their respective growing season and can weight each interval[1] up to 40 percent so that intervals the producer believes are more important have a larger impact on potential indemnity payments.

The choices discussed above are factors in determining the cost of the producer's premium, the value of a potential indemnity payoff, and the value of the subsidy that the producer receives (USDA, FDIC, RMA 2013). Subsidies are applied as a percent of premium cost and vary by the level of coverage the producer selects. The subsidy levels are set for each state by the Annual Commodity Report for the program (USDA, RMA 2015). The 2015 subsidy levels for Oklahoma are 59 percent for 70 and 75 percent coverage levels, 55 percent for 80 and 85 percent coverage levels, and 51 percent for a 90 percent coverage level. Thus, the producer also chooses the percent of the premium that will be paid by the RMA when choosing a coverage level. For example, if the actuarially fair premium total cost is $2.16 for $21.60 of coverage per acre ($20 county base multiplied by 120 percent productivity factor multiplied by a 90 percent coverage level), the Federal Crop Insurance Corporation (FCIC) pays a 51 percent subsidy so that the producer only pays $1.06 per acre for the insurance (USDA, FDIC, RMA 2013). In general, higher productivity factors and coverage levels lead to higher premiums, higher potential indemnity payoffs, and lower subsidy levels in terms of percent of premiums. If the goal were to maximize the amount of total subsidy in dollars, a producer should sign up for CAT coverage and also buy up coverage at the 90 percent coverage level and with a 150 percent productivity factor.

Similar to other crop insurance programs, the FCIC set limits pertaining to the maximum subsidy level and the maximum available funds for the program. The maximum subsidy possible is 60 percent of the premium amount for buy-up coverage while CAT coverage is fully subsidized. The maximum annual amount allocated to this program from the FCIC fund is $12.5 million for FY2015-2018 (Shields 2014). Funding for other expenses are outlined by Shields, 2014: "administrative and operating expenses are to be reimbursed as with other policies, but federal reinsurance, research and development costs, and other reimbursements or maintenance fees are not provided for these policies. Policies may be sold by the approved insurance provider that submits the application as well as others who agree to pay maintenance fees to the submitting provider. Policies cannot be substantially similar to privately available hail insurance" (p. 9).

Conceptual Framework

The general choice that a forage producer faces when crop insurance is available is similar to that of other insurance programs where the producer chooses the coverage level and an indemnity payment is triggered if production falls below a certain "threshold" level. However, the rainfall index values are used in replacement of the production levels. As most forage production operations are only one piece of a larger agricultural operation, the objective function should be considered as one of many within a whole-farm optimization problem.

Following Coble et al. (1997), we assume the producer will maximize expected utility of wealth when considering the option of participation in the crop insurance program. Along with the discrete insurance participation choice, the producer also chooses the preferred coverage level and productivity factor. The coverage level choice dictates the percentage of the rainfall index that will trigger an indemnity payment. A higher coverage level will result in a higher premium. The productivity factor choice is simply an adjustment to the county base production value per acre. The range of possible productivity factors is 60 to 150. Assuming the type of crop to be planted has already been chosen, the risk averse producer's expected utility objective function is written as

$$(1) \qquad \max_{\substack{A\in\{0,1\} \\ 70\leq\delta\leq 90 \\ 60\leq\varphi\leq 150}} EU(\pi) = \iint U(\pi) f(\Theta) dIdY$$

$$\text{s.t. } \pi = PY + A(k(\max(\delta - I, 0)) - c(\delta,\varphi) + s(\delta,\varphi)) - \boldsymbol{r}'\boldsymbol{z}$$

$$\Theta = [I, Y]$$

$$k = B\delta\varphi$$

$$U'(\pi) > 0\,, \quad U''(\pi) < 0$$

where A is a discrete choice variable which equals one if the producer purchases crop insurance and zero if he does not, δ denotes the threshold coverage level choice ranging from 70 to 90 percent, φ is the productivity factor adjustment choice, $EU(\pi)$ is expected utility of profit, I is the actual index value and will trigger an indemnity payment if lower than the chosen threshold level of δ, P is the price for each unit of yield, k is the value of the indemnity payment per acre and is calculated as the product of the county base value per acre (B), the chosen coverage level, and the productivity factor, c is the cost of the insurance premium, s is the value of the subsidy in dollars, both c and s vary with the coverage level choice, $\boldsymbol{r}$ is a vector of other input costs, $\boldsymbol{z}$ is a vector of other inputs, Θ represents the joint distribution of the index value and yield, and $U'(\pi)$ and $U''(\pi)$ are the first and second derivatives of the profit function, respectively.

Note in equation (1) the mechanism which triggers an indemnity payment. The producer chooses a coverage level as a percentage of the historical average annual rainfall for the relevant grid. An indemnity is triggered only if the rainfall index falls below the chosen coverage level and not if it simply falls below the historical average. Further, the amount of the indemnity payment depends on the coverage level and productivity factor choices. Thus, the producer has many factors to consider when selecting the levels of his choice variables.

Since we are interested in the relationship between yields, actual rainfall, and the rainfall index used in the Annual Forage pilot program, we are specifically interested in the relationships of their distributions. The joint distribution of Θ represents the interaction between the rainfall index and forage yield. Also, nested within this distribution is interaction of actual rainfall with the rainfall index and yield. This joint distribution is the area of focus for this paper as we are interested in the relationships between the rainfall index, forage yield, and actual rainfall.

Data

We are fortunate to have data from a long-term study of annually established cereal rye-ryegrass forage production at the Samuel Roberts Noble Foundation's Red River Farm located near the community of Burneyville in south-central Oklahoma from 1974 until the experiment was discontinued in 2008. This is a relatively long series of continuous agronomic data that allows many years for which to consider the effectiveness of the design of the RIAFP. This experiment was initially used to evaluate the effect of nitrogen fertilization rate and harvest timing on annual forage production but has since been used to analyze various lime and nitrogen application questions (i.e. Tumusiime et al. 2011a; Tumusiime et al. 2011b; Altom et al. 1996; Altom et al. 2002). This expansive data set includes actual forage clippings in pounds, lime and fertilizer treatments, and planting and clipping dates over 33 years for a total of 3,845 plots. Plots differed by varying treatments of fertilizer and lime. Forage yields were determined by clipping each 12×13 foot plot multiple times per year to simulate grazing. Forage yield is split between clipping season. As most plots in the data were planted in September, fall forage yield is calculated as the sum of clippings from the planting date up to March 1st. Clippings that occurred between March first and the final clipping of the year (usually near the end of May) are considered spring forage. The annual forage yield for each plot is the sum of fall and spring forage yields. Descriptive statistics for these data are provided in table 1. We use average annual forage yield as the variable of interest in this article which we call average annual yield.

We are ultimately interested in how closely the yields each year follow the RMA rainfall index used to trigger indemnity payoffs in the RIAFP. Therefore, to calculate a single yield observation for each year or season, we must first determine which observations should be used since the data include yields from plots with different fertilizer and lime treatments. Because the effects of fertilizer treatments are not the focus of this paper, we use only the yields from plots with nitrogen application of 100 (lb acre^{-1}) which is consistent with the Samuel Roberts Noble Foundation recommendation as well as results from previous work using data from the Red River Farm (Tumusiime et al. 2011b). Further, for years 1980 to 2008, we use only plots with lime treatments. Prior to 1980, none of the plots were treated with lime because no lime was needed. We account for fall and spring clippings by treating a year as a crop year. All plots were initially planted in September or early October and clipped for the last time within one month of the first week of May. To achieve a single yield observation for each plot for each season each year, we simply sum the yields from each clipping. Seasons are split at March 1st. All clippings prior to March 1st are considered fall clippings with the others considered spring clippings. Thus, the average annual forage yield for each year is the average total plot yield or the sum of fall and spring clippings across plots meeting the above criteria for each year.

We treat the sum of fall clippings as growing season one forage yield defined by the RIAFP. The criteria to which plots must adhere are the same as for the average annual forage yield, except that the 100 (lb acre^{-1}) of nitrogen must be applied during the fall season instead of across fall and spring seasons. Therefore, growing season one forage yield is defined as the average sum of fall clippings for each year.

Rainfall index data for the grid in which the farm is located are collected from the USDA Risk Management Agency's (RMA) decision tool (AF, GMS, and RMA 2014). Further, actual rainfall data are available from two sources: a Mesonet weather data collection station located at the Red River Farm for years 1993 to 2008 and a National Climatic Data Center (NCDC) weather data collection station in nearby Marietta, OK for 1974 to 2008 (Mesonet 2014; NCDC, NOAA 2014a). The distance between Marietta, OK and the Samuel Roberts Noble Foundation Red River Farm in Burneyville, OK is approximately 6 miles. Figure 1 shows the RMA decision tool map of Burneyville and Marietta with the grids overlaid (AF, GMS, and RMA 2014). Because the rainfall index is calculated using the total precipitation over two month periods, we create matching periods using the actual rainfall data by summing the rainfall in the respective months of each period. Since all of the plots in our data were planted during growing season one as specified by the provisions of the RIAFP, only the two month intervals within September to March (USDA, FDIC, RMA 2013). Thus, we are left with six growing season one rainfall intervals for each of the actual Burneyville rainfall, actual Marietta rainfall, as well as the rainfall index. Intervals outside of those allowed in growing season one are used when analyzing annual forage yield because some of the clippings occurred in months later than for which the RIAFP provides rainfall index intervals.

The rainfall index is calculated from data collected by undisclosed NOAA weather stations from 1948 to 2008 (RMA 2014b). The RMA does not disclose which stations are used in the rainfall index calculation to prevent producers from tracking these stations to predict whether an indemnity will be paid (RMA 2014a). While we cannot know exactly which stations are used, it is known that NOAA used only stations that reported at least 75 percent of the time from 1948 to 2010. From these data, interpolation is used to create 0.25° latitude by 0.25° longitude grids (approximately 12 by 12 miles in Oklahoma) using a modified inverse distance weighting technique based on Cressman's (1959) methods (RMA 2014b)[2]. Four weather stations are used daily to calculate precipitation and the weight of each station is determined by its distance from the grid. These four stations can change daily depending on how often they report (RMA 2014a). Therefore, the weight of the closest reporting weather station has the greatest impact on each specific daily average.

From these daily precipitation data, two month intervals were calculated by summing all of the days within the interval. Thus, for growing season one, six two month intervals of total precipitation were created beginning with the September-October interval. Then, the rainfall index was calculated for each specific interval using the deviation between that interval and a historical long term average rainfall (RMA 2014b). The historical average was calculated using data from 1948 to two years prior to the interval of interest and was adjusted to reduce the likelihood of extreme weather events affecting the index value. The final rainfall index is calculated by dividing the current interval rainfall by the historical long term average rainfall and multiplying by 100. A step by step process of this calculation as provided by RMA (2014b) is shown in Appendix A.

While we cannot be certain which stations are used in the calculation of the rainfall index due to the nondisclosure of the NOAA weather stations used for the calculation, the Marietta rainfall weather station used as a measure of actual rainfall data is listed as a NOAA weather station (NCDC, NOAA 2014b). It is possible that data from this station were used in the calculation of the rainfall index for the grid in which Burneyville lies. There are 15 stations within 50 miles of the Noble research farm in Burneyville that have reported weather data at least 75 percent of the time since 1948 (NCDC, NOAA 2014b). The Marietta, OK station is the closest (6 miles) and the Muenster, TX station is the next closest at approximately 17 miles.

Empirical Application

The key assumption of the RIAFP is that forage production is correlated with the rainfall indices and, thus, a decrease in the index would result in a decrease in forage production. Thus we are interested in the relationship of the yield and rainfall index variables within the joint distribution $f(\Theta)$ from equation (1).

With a single annual observation for yield, the data generating process is specified as

$$Y_t = \beta_0 + \boldsymbol{\beta_i}'\boldsymbol{R_t} + \varepsilon_t \quad (2)$$

where Y_t represents average annual spring forage yields (lb acre^{-1}) for each year t where $t = 1, \ldots, 34$ which corresponds with years 1974 to 2008, $\boldsymbol{R_t}$ is a vector of the rainfall index intervals provided by RMA, ε_t are the experimental error terms where $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$ and β_0 and $\boldsymbol{\beta_i}$ are parameters to be estimated. Because we are essentially estimating a linear approximation under the assumption of normality, the cross moments between the dependent variable and independent variable indicate their relationship. Thus, we calculate the Pearson product-moment correlation specified as

$$(3) \qquad r = \frac{n(\sum R_t Y_t) - (\sum R_t)(\sum Y_t)}{\sqrt{\left[n \sum {R_t}^2 - (\sum R_t)^2\right]\left[n \sum {Y_t}^2 - (\sum Y_t)^2\right]}}$$

where r is the Pearson product-moment correlation and n is the number of observations to show this relationship. The relationship between forage yield and the rainfall index as well as the relationships between the rainfall index and actual rainfall can be estimated using the same method.

Since the data do not fit perfectly into the design of the program for growing season one, we separate the estimation into separate designs. To match the rainfall index intervals to the actual production process used, we estimate correlations between annual forage yield and the rainfall measures for each interval within the actual growing season, September to May. To test the design of the program using only those yields fitting within growing season one, we estimate correlations between annual growing season one forage yields and the rainfall measures for each interval within September to March.

Beyond correlations, we also test whether there are other variables along with rainfall within our data that effect forage yield using a linear regression model specified as

$$(4) \qquad Y_t = \alpha_0 + \alpha_1 t + \alpha_2 D_t + \boldsymbol{\alpha_i}' \boldsymbol{R_t} + v_t$$

where t denotes a time trend, D is the number of days between the planting date and September 1 for each year, $\alpha_0, \ldots, \alpha_i$ are the parameters to be estimated, v_t are the experimental error terms where $v_t \sim N(0, \sigma_v^2)$. Figure 3 indicates a likely structural change beginning around 1993 as forage yields increase after remaining relatively flat from 1974 to 1993. Thus, a Chow test for structural change is performed and indicates a significant structural break at year 1993 (Chow 1960). Therefore, a multiple regression format is used such that the regression in equation (4) is performed separately for the 1974 to 1992 and 1993 to 2008 time periods.

Due to the program design, at least three rainfall intervals must be chosen out of the September to March period used for growing season one. Since there are only seven months and intervals chosen cannot overlap, a producer can choose to leave out either September, November, January, or March. To estimate just two models where all possible intervals are used at least once, we estimate linear models for two interval combinations: one where September is the month left out and one where March is the month left out.

Results

The estimated Pearson product-moment correlations between annual forage yield and the rainfall variables are provided in table 2 for each interval within the actual growing season. As shown, the correlations are surprisingly nearly all negative[3], though only the September-October intervals for the rainfall index and actual rainfall in Burneyville are statistically significant at conventional levels. These results seem to follow a visual check of the data provided in figure 2 as annual forage yield and the rainfall index do not appear to move together. This significant negative correlation is likely due to the fact that September and October are the planting months for forage in the experiment and increased rainfall can delay planting. The results for the full data series using the Marietta, OK actual rainfall are comparable to the results using the Burneyville, OK data.

Of particular interest is the correlation between the rainfall index and actual forage yield at the site of the plots. Table 3 provides the correlations between the rainfall index and the actual rainfall variables. As shown, all of the intervals for the rainfall index have high positive correlations with each actual rainfall variable implying that the rainfall index performs very well as an indicator of actual rainfall, a key assumption of the Annual Forage Pilot program.

To test how well the design of the program works for data that fit the specific intervals available in growing season one, table 4 presents the correlations between forage yield in growing season one and the rainfall variables. The correlations are split into separate time frames to account for the apparent structural change beginning in 1993. The correlations for the 1974 to 1992 period are very low and often negative, although none are statistically significant. For the 1993 to 2008 time period, the intervals between October and February all have the expected positive sign for the correlation between yield and actual rainfall in Burneyville. Further, the correlations for the December-January interval are positive and statistically significant at conventional levels for all of the rainfall variables.

Table 5 and table 6 report linear regression coefficients for the effects of planting date, year, and the rainfall variables on growing season one forage yield. As shown in the model using the Burneyville actual rainfall intervals, each additional day waited to plant from September 1st increases growing season one forage yield by 71 to 151 pounds depending on the intervals chosen. The January-February interval is positive and statistically significant in the Burneyville actual rainfall model implying that a one inch increase in the cumulative rainfall during January and February leads to a 202.27 pound increase in growing season one forage yield. Differing from the estimated correlation in table 4, the coefficient for the September-October interval is positive, although not statistically significant.

For the rainfall index models, the November-December interval is positive and statistically significant. The estimate implies that a one unit (or percent) increase in the rainfall index leads to a 14.9 pound increase in growing season one forage yield. The September-October interval is negative and significant. Although only six miles away from the location of the plots where the data were collected, none of estimates in the Marietta, OK actual rainfall model are significant and these two models also are the poorest performing at explaining variation in growing season one forage yield as shown by the R^2 values. The Marietta model including the September-October interval explains only 40 percent of the variation in forage yield while the Burneyville model for the same intervals explains 83 percent of the variation in yield.

For a producer in Burneyville, OK, the RIAFP would have triggered an indemnity payment under CAT coverage five years from 1974 to 2014 or about thirteen percent of the time for a total payoff of $14.67 and a total premium subsidy of $31.98 per acre. The number of payoffs increases to 32 out of the 40 years for buy-up coverage at a 90 percent coverage level if the intervals chosen were October-November, December-January, and February-March. These intervals were chosen because the December-January interval which we find to have the most significant correlation with forage yield is included. Using the 90 percent coverage level and the

150 percent productivity factor which maximizes the total subsidy dollars, a producer would have paid $461 in premiums with payoffs totaling $661 per acre. Out of the 40 years analyzed, the annual payoff would have exceeded the producer's portion of the premium 20 times. For this scenario, the total subsidy paid as a 51 percent of the total premiums would have been $480.09.

In total, a producer in Burneyville, OK from 1974 to 2014 would have gained an extra $215 per acre by participating in the RIAFP at the highest levels allowed. Without the subsidies for both CAT coverage and buy-up coverage, the insurance would not have been profitable as producers would have paid $298 more in premiums than they would have earned in payoffs per acre.

Conclusions

We find that the rainfall index seems to be well designed as it has high positive correlation with actual rainfall. Thus, the program design will likely work well at insuring against a particularly dry year which is a key purpose of the RIAFP. However the rainfall index would have done little to provide yield risk protection for our specific data. When considering only the yields within the growing season one as defined by the RIAFP, we find some of the expected positive correlation between the rainfall indices and forage yield. This implies that the program might work better for crops with total yields that occur in months matching the available rainfall index intervals.

Although including all of the index intervals in which the forage was actually harvested did not provide any additional yield risk protection for our data, the program would benefit from allowing producers to select intervals for any months prior to when they expect to harvest. Currently producers are limited to which intervals they may select depending on when the crop is planted. Many cool season forages such as ryegrass and winter wheat are planted in early fall and harvested in months later than for which the RIAFP provides index intervals. A possible alternative would be to allow producers to select rainfall index intervals containing the late spring months for forage planted in growing season one.

The program, especially the fully subsidized CAT coverage, offers clear advantages to annual forage producers. Due to the high subsidy levels and the correlations between rainfall and the rainfall index, eligible expected profit maximizing producers should sign up for CAT coverage and strongly consider the buy-up coverage as long as this does not affect their eligibility for other programs. Our results suggest that the December-January interval should be selected for buy-up coverage as it is positive and significantly correlated with yield.

One of the contentious points in the recent farm bill debate was equity, both in terms of regional equity as well as in terms of providing subsidies to producers of nonprogram crops such as annual forage (Freshwater 2015). Freshwater (2015) argues that farm programs are simply a way to provide equity by transferring federal dollars to rural areas and thus, a farm program should be viewed not only from an efficiency standpoint, but also by how well it transfers federal dollars to underserved areas. While the program seems to provide drought risk but do little to reduce yield loss risk, the RIAFP can still meet what is a key goal – to transfer income to annual forage producers.

The implications for producers are clear; since the program does little to reduce yield loss risk, sign up for the program and choose the options that maximize the subsidy dollars. Had the

RIAFP been available, signing up for CAT coverage and buy up coverage at the maximum levels would have led to a $215 increase per acre in total producer profit over the past 40 years. Without the subsidy, the same coverage would have led to a $298 decrease per acre in producer profit. Thus, the program clearly would have transferred equity to producers in this area.

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Endnotes

[1] The special provisions for the RIAFP set the maximum weight for any interval at 40 percent. Thus, a producer must choose three intervals that sum to 100 percent. More than three intervals is not possible as it is not possible to choose multiple intervals consisting of the same month. For instance, If the September-October interval is chosen, then the October-November interval cannot be selected (USDA, RMA 2015).

[2] While not used in this paper, we note that the interpolation technique used for years 2010 and later is the optimal interpolation technique as discussed by Gandin (1965) and Xie et al. (2007).

[3] In an actual grazing situation, a negative correlation would not be a surprise since cattle would trample forage into the mud. However, the plots within our data were clipped, not grazed.

Table 1. Descriptive Statistics for Burneyville, OK Forage Trials for 1974 to 2008

Variable	Mean	Std. Deviation	Min	Max
Average forage yield (lb. acre^{-1})	3456.7	2144.8	1206.1	7597.3
Average fall forage yield (lb. acre^{-1})	1486.6	798.7	454.7	3192.6
Average Burneyville grid rainfall index[a]	109.3	57.5	14.1	369.6
Average Burneyville, OK actual rainfall[b] (inches per two month period[c])	5.3	3.4	0.2	20.3
Average Marietta, OK actual rainfall (inches per two month period[c])	6.2	4.1	0.0	27.2

Note: N=33

[a] We present the average value across all index intervals from September to May.

[b] N=16 for this variable as data were only available from 1993 to 2008.

[c] Because the rainfall index is only available over two month intervals, we present the actual rainfall data in a consistent manner. Therefore, the mean for this variable is the average cumulative rainfall across each two month period from September to May.

Table 2. Pearson Correlations Between Annual Forage Yield and Rainfall Variables for 1974 to 2008

Months(Cumulative Rainfall)	Index (RMA)	Burneyville[a] (Mesonet)	Marietta (NCDC)
September-October	-0.343*	-0.664**	-0.283
	(0.051)	(0.007)	(0.117)
October-November	-0.176	-0.255	-0.151
	(0.327)	(0.359)	(0.401)
November-December	-0.190	-0.367	-0.119
	(0.291)	(0.179)	(0.509)
December-January	-0.185	-0.186	-0.144
	(0.302)	(0.507)	(0.425)
January-February	-0.254	-0.218	-0.170
	(0.154)	(0.436)	(0.353)
February-March	-0.262	-0.338	-0.121
	(0.140)	(0.218)	(0.511)
March-April	-0.135	-0.123	-0.022
	(0.454)	(0.663)	(0.904)
April-May	-0.240	0.041	-0.077
	(0.178)	(0.885)	(0.669)

Note: N=33. Prob >| r | in parentheses. Triple asterisk (***), double asterisk (**) and single asterisk (*) denote significance at the 1%, 5%, and 10% levels respectively.

[a] N=15 for this variable as data were only available from 1993 to 2008.

Table 3. Pearson Correlations Between Burneyville, OK Rainfall Index Intervals and Actual Rainfall Intervals for 1974 to 2008

Months(Index Value)	Burneyville (Mesonet)	Marietta (NCDC)
Index (RMA) September-October	0.930***	0.959***
	(<.001)	(<.001)
Index (RMA) October-November	0.980***	0.967***
	(<.001)	(<.001)
Index (RMA) November-December	0.966***	0.970***
	(<.001)	(<.001)
Index (RMA) December-January	0.972***	0.971***
	(<.001)	(<.001)
Index (RMA) January-February	0.956***	0.943***
	(<.001)	(<.001)
Index (RMA) February-March	0.942***	0.937***
	(<.001)	(<.001)
Index (RMA) March-April	0.864***	0.915***
	(<.001)	(<.001)
Index (RMA) April-May	0.901***	0.899***
	(<.001)	(<.001)

Note: N=33. Prob >| r | in parentheses. Triple asterisk (***), double asterisk (**) and single asterisk (*) denote significance at the 1%, 5%, and 10% levels respectively.

Table 4. Pearson Correlations Between Growing Season One Forage Yield and Rainfall Variables for 1974 to 1992 and 1993 to 2008

	1974 to 1992		1993 to 2008		
Months (Cumulative Rainfall)	Index (RMA)	Marietta (NCDC)	Index (RMA)	Burneyville (Mesonet)	Marietta (NCDC)
September-October	0.114	0.097	-0.339	-0.082	-0.464
	(0.698)	(0.742)	(0.257)	(0.800)	(0.129)
October-November	-0.213	-0.194	0.025	0.133	-0.035
	(0.465)	(0.506)	(0.936)	(0.681)	(0.910)
November-December	-0.091	-0.038	0.301	0.418	0.129
	(0.757)	(0.898)	(0.318)	(0.177)	(0.676)
December-January	-0.036	-0.027	0.548*	0.601*	0.488*
	(0.902)	(0.928)	(0.052)	(0.039)	(0.091)
January-February	-0.054	0.105	-0.025	0.116	-0.278
	(0.856)	(0.722)	(0.936)	(0.719)	(0.382)
February-March	-0.017	0.106	-0.179	-0.030	-0.397
	(0.954)	(0.720)	(0.558)	(0.926)	(0.201)

Note: Prob >| r | in parentheses. Triple asterisk (***), double asterisk (**) and single asterisk (*) denote significance at the 1%, 5%, and 10% levels respectively.

Table 5. Ordinary Least Squares Coefficients for Rainfall Intervals' Effect on Growing Season One Forage Yield for 1993 to 2008 Beginning with September-October Interval

	OLS Models		
Variable	Index (RMA)	Burneyville (Mesonet)	Marietta (NCDC)
Intercept	4231.54*	-1638.92	2280.50
	(1886.14)	(1904.81)	(2192.76)
Trend	-70.01	-52.99	-27.89
	(40.01)	(30.65)	(58.76)
Planting days from September 1st	16.64	151.03**	23.35
	(30.00)	(45.86)	(38.81)
September-October Interval	-20.50*	260.42	-75.38
	(8.08)	(143.41)	(92.91)
November-December Interval	14.90**	-45.34	173.61
	(4.35)	(132.74)	(123.11)
January-February Interval	-5.22	202.27*	-133.03
	(3.66)	(100.76)	(216.71)
R^2	0.71	0.83	0.40

Note: Standard Errors in parentheses. Triple asterisk (***), double asterisk (**) and single asterisk (*) denote significance at the 1%, 5%, and 10% levels respectively.

Table 6. Ordinary Least Squares Coefficients for Rainfall Intervals' Effect on Growing Season One Forage Yield for 1993 to 2008 Beginning with October-November Interval

	OLS Models		
Variable	Index (RMA)	Burneyville (Mesonet)	Marietta (NCDC)
Intercept	687.17	1505.38	1025.18
	(1684.32)	(1268.91)	(1721.60)
Trend	-4.81	-65.94	-22.29
	(52.47)	(42.77)	(51.77)
Planting days from September 1st	38.82	71.50**	15.67
	(37.66)	(25.42)	(35.99)
October-November Interval	2.51	87.90	9.08
	(4.42)	(52.38)	(76.31)
December-January Interval	5.71	80.53	129.87
	(3.84)	(75.92)	(143.13)
February-March Interval	-1.66	38.50	-116.78
	(5.96)	(76.00)	(136.05)
R^2	0.44	0.73	0.35

Note: Standard Errors in parentheses. Triple asterisk (***), double asterisk (**) and single asterisk (*) denote significance at the 1%, 5%, and 10% levels respectively.

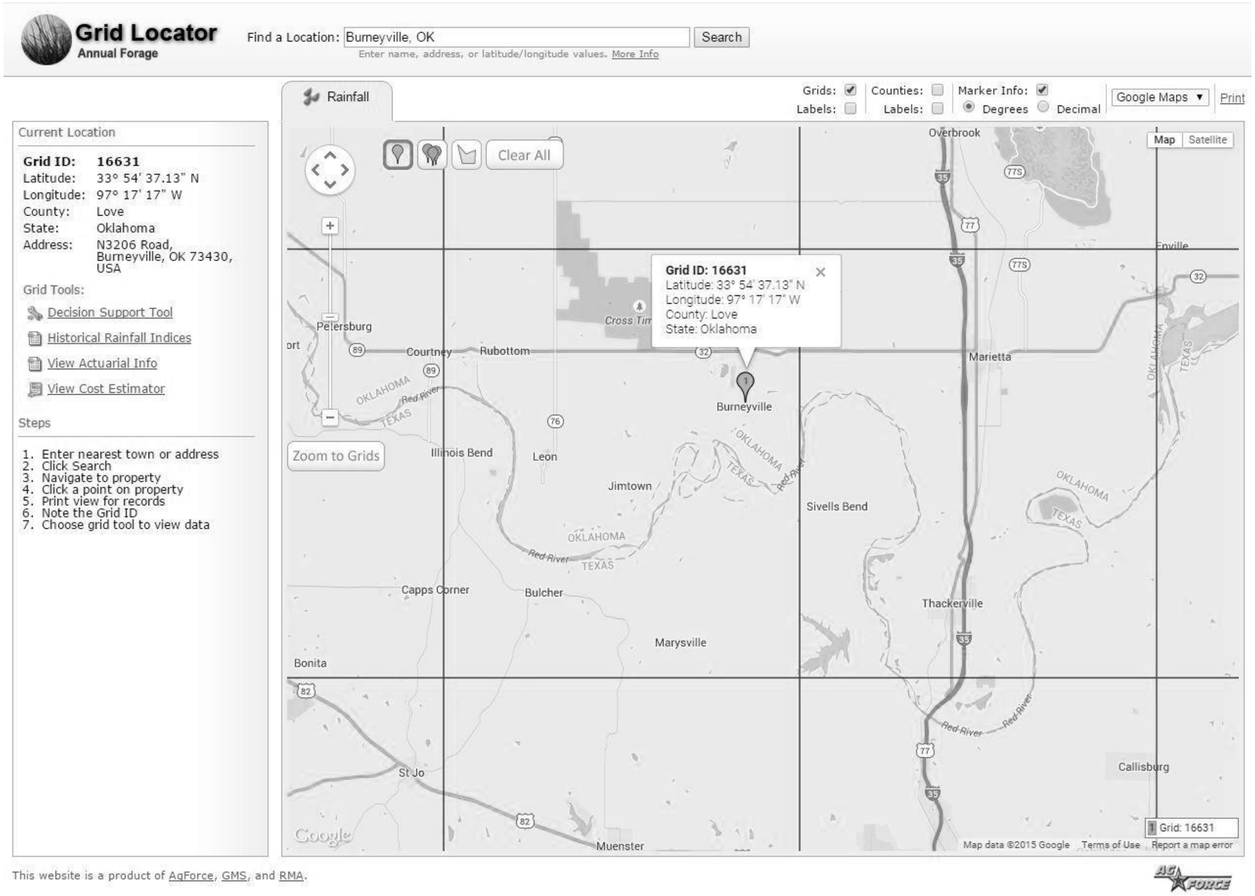

Figure 1. RMA annual forage decision tool map of Burneyville, OK in relation to Marietta, OK with rainfall index grids overlaid.

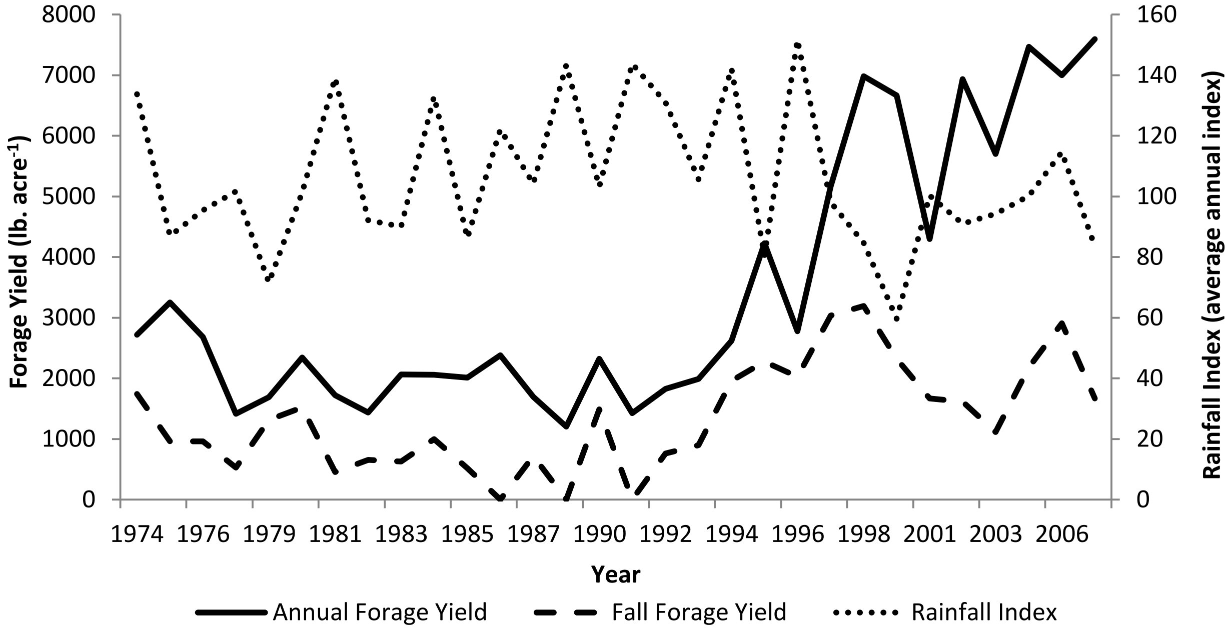

Figure 2. Average spring forage yield in relation to annual average annual rainfall index for the grid in which Burneyville, OK is located.

Appendix A

Step by step calculation of rainfall index as provided by RMA (2014b)

1. The system first counts the number of sample values in the historical period (1948 to two years prior to the year and interval of interest) For example, if 2009 is the year for which Rainfall Index is being calculated, then the historical period for calculating the long-term average is January 1, 1948 – December 31, 2007. The count is used as the sample size for long term average calculations.

2. The system then conducts the capping by assessing how many samples are outliers or outside of the typical range of rainfall values. For the analysis, 99.99% of all values are considered typical rainfall values; the remaining 0.01% are considered outliers. For this calculation, the sample size determined in step 1 above is multiplied by 0.0001, and the result is rounded to a whole value. The result is the number of outliers that will be removed from the index calculation. For example if the result is 3 outliers, then the third highest value becomes the cap value. Therefore all rainfall events that are greater than the cap value become the cap value. This analysis is conducted for each individual grid in the NOAA data.

3. The system then calculates the historical average for each interval. Intervals start each month and continue for a span of two months (e.g., Interval 1 contains the months of January and February, Interval 2 is February to March, and so on until every month is represented). There are 11 intervals per year. For each target grid, the rainfall is accumulated (summed) for all days in the interval and then a long-term average is calculated by averaging the accumulated rainfall across years. The result becomes the historical average for the interval of interest. As with step 2, the historic index is calculated for each grid in the database.

4. Rainfall for the current interval of interest is accumulated for the interval period for the target grid. This becomes the current interval rainfall.

5. Finally, the Rainfall Index is calculated as $\text{Rainfall Index} = \frac{\text{Current Interval Rainfall}}{\text{Long term Average Rainfall}} \times 100.$