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Basis Risk in the Pasture, Rangeland, and Forage Insurance Program: Evidence from California

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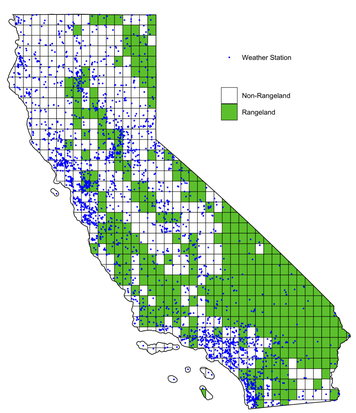
Background

- The USDA RMA introduced the Pasture, Rangeland, and Forage (PRF) Insurance Program in 2007 to mitigate weather-related losses in forage production for grazing livestock or hay harvested.
- 98.7 million acres were enrolled in the program in 2017 a total liability of $2.45 billion in 2018 (RMA 2018).
- PRF insurance contracts use a bimonthly rainfall index computed as the ratio of rainfall in the contract year to the average rainfall from 1948 to 2 years prior.
- Given that the index is an imperfect predictor of individual losses suffered by the insured, producers are still subject to residual risk, referred to as basis risk.
- Previous studies have attempted to quantify basis risk for perennial pasture ecosystems in the U.S. Midwest.
  - Yu et al (2019) estimated that basis risk at three university-managed ranches in Kansas and Nebraska was 26%.
  - Maples, Brorsen, and Biermacher (2016) found that the rainfall index was a poor predictor of forage outcomes in Oklahoma.
- However, no study has yet quantified basis risk for the semi-arid rangelands and annual-grass-type forage production systems that characterize California's ecosystem.

Objectives

- Quantify basis risk associated with PRF Insurance in a semi-arid Mediterranean climate where precipitation is confined to a single season during which other abiotic factors are unfavorable for vegetation growth.
- Examine basis risk across a substantially larger geographic area than previously studied, approximately 62.7 million acres of rangelands in California, using the Normalized Difference Vegetative Index (NDVI) to quantify forage production.
- Assess the quality of the PRF Insurance contract by considering the degree to which indemnity payments cover forage losses

Figure 1. California Rangelands - NOAA CPC Grids and Weather Stations



Data

- **Rainfall Index** The USDA RMA uses interpolated rainfall data from the NOAA Climate Prediction Center to generate bimonthly rainfall index values for 0.25°latitude by 0.25°longitude grids across the continental United States. We scraped both index values and rainfall measurements from the RMA's PRF Support Tool for all 750 grids in California from 1948 to 2018. Given that PRF Insurance only became available in California in 2011, we restrict our sample to the 2011 to 2018 period.
  - Index values are in "percent of normal" terms with 1.0 representing average precipitation for a bimonthly interval, > 1.0 being above normal, < 1.0 being below normal
  - An indemnity is paid out only if the realized index value is below the contract coverage rate (0.70, 0.75, 0.80, 0.85, 0.90)
- **Forage Production** NDVI measurements are gathered from the USGS Earth Explorer Web Application for 2003 to 2018 which we aggregate to the same grids as the rainfall measurements. We use average NDVI during the March, April, May period to compute a peak forage production index using the same procedure used for the rainfall index.

Methods

Correlative Analysis

We estimate the degree of correlation between the rainfall and NDVI forage production indices for each bimonthly rainfall index interval. We lag index values for the Oct-Nov and Nov-Dec index intervals because rainfall in these periods determines forage in the following year. (Table 1)

Estimation of Basis Risk

Following Elabed et al. (2013) and Yu et al. (2019), we compute false negative probability (FNP) (i.e., an insured producer suffers a losses without receiving an indemnity payment) as a measure of basis risk:

$$FNP_{g,i,t} = \text{Prob}(N_{g,t} < C | RI_{g,i,t} \geq C)$$

where C is the coverage rate selected by the insured, and $RI_{g,i,t}$ and $N_{g,t}$ are the rainfall index and forage index, respectively, for interval i, in grid g, and year t. (Table 2)

PRF Insurance Contract Quality

To characterize contract quality, we report the frequencies of false negatives, false positive, underpayments, and overpayments for a subset of rangeland of grids in California with a county base value of $13.40 from 2011 to 2018. (Table 3)

Results

Table 1. *Correlation of Rainfall and Forage Production*
Rangelands Below 1524 m

Forage Index	Oct-Nov (t-1)	Nov-Dec (t-1)	Jan-Feb (t)	Feb-Mar (t)	Mar-Apr (t)	Apr-May (t)	May-Jun (t)
May-Jun (t)	0.04	0.21	0.38	0.42	0.28	0.09	-0.04
Apr-May (t)	0.01	0.22	0.38	0.46	0.27	0.03	
Mar-Apr (t)	0.02	0.26	0.32	0.29	-0.03		
Feb-Mar (t)	0.19	0.26	0.16	0.10			
Jan-Feb (t)	0.16	0.15	-0.05				
Nov-Dec (t-1)	0.23	-0.14					
Oct-Nov (t-1)	0.18						
	Rainfall Index						

Table 2. *Average False Negative Probabilities by Interval and Coverage Rate for Rangelands [Lower-Elevation Rangelands], 2005-2018*

Interval	Coverage Rate 0.70	0.75	0.80	0.85	0.90
			---- *(%)* ----		
Oct – Nov *(t-1)*	60 [54]	55 [50]	49 [45]	44 [41]	41 [39]
Nov – Dec *(t-1)*	30 [18]	30 [22]	29 [25]	33 [30]	36 [34]
Jan – Feb *(t)*	38 [25]	31 [22]	28 [23]	28 [23]	27 [23]
Feb – Mar *(t)*	30 [14]	25 [13]	23 [15]	24 [19]	26 [22]
Mar – Apr *(t)*	55 [44]	50 [42]	45 [40]	44 [40]	42 [40]
Apr – May *(t)*	63 [55]	55 [49]	48 [44]	47 [43]	42 [39]
May – Jun *(t)*	23 [17]	25 [20]	27 [24]	30 [28]	31 [30]

Source: Author calculations. Notes: Estimated false negative probabilities for rangelands at elevations less than 1524 m are provided in square brackets. Note: Only index intervals relevant for the forage production year are provided.

Table 3. *Measures of PRF Insurance Contract Quality, 2011-2018*

	$N_{g,i,t} <$ 1.0	$N_{g,i,t} \geq$ 1.0	*False Negative* $N_{g,i,t} < 1.0$ & $RI_{g,i,t} \geq C$	*False Positive* $N_{g,i,t} \geq 1.0$ & $RI_{g,i,t} < C$	*Under-Payment* $I_{g,i,t} < Loss_{g,i,t}$	*Over-Payment* $I_{g,i,t} \geq Loss_{g,i,t}$
	# of grids	*# of grids*	*# of grids*	*# of grids [avg. indemnity ($)]*	*# of grids [avg. indemnity - avg. loss ($)]*	*# of grids [avg. indemnity - avg. loss ($)]*
Oct-Nov[1]	866	174	358	100 [6.29]	55 [-1.57]	453 [7.76]
Nov-Dec[1]	866	174	332	24 [6.69]	92 [-1.51]	442 [6.43]
Jan-Feb	866	174	172	61 [6.50]	115 [-1.70]	579 [6.26]
Feb-Mar	866	174	118	94 [4.74]	82 [-1.19]	666 [5.79]
Mar-Apr	866	174	264	143 [10.42]	90 [-1.76]	512 [6.43]
Apr-May	866	174	321	133 [9.14]	49 [-1.31]	496 [7.00]
May-June	866	174	258	114 [9.81]	63 [-1.53]	545 [8.54]
Total [avg.]	6,062	1,218	1,823	669 [8.15]	546 [-1.53]	3,693 [6.84]

Note: A=1.0, B_g=13.40, C=0.85, P=1.0, and ϕ_i=1.0; [1] Oct-Nov and Nov-Dec intervals are lagged (i.e., in the previous calendar year, relative to forage estimates).

Conclusions

- The rainfall index is poorly correlated with forage production in California. (Table 1)
- Overall basis risk was determined to be 25% – 47% for the 85% coverage rate predominantly selected by producers in California. Producers may be able to reduce some of this temporal basis risk by selecting index intervals to insure prior to the periods when they expect forage production. (Table 2)
- When indemnities are paid, producers often receive more than the monetary value of the deficiency in forage production. In instances where forage losses did occur and indemnities were paid, 12% of the grid-year combinations payments were insufficient in compensating producers for on-the-ground losses. (Table 3)

References

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