Quantifying Basis Risk in Rainfall Index Insurance:

Spatial Evidence from Nebraska Rangelands

Wajdi Belgacem[1] Jay Parsons[1]

[1]Department of Agricultural Economics, University of Nebraska–Lincoln

`wajdi.belgacem@unl.edu` `jparsons@unl.edu`

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Wajdi Belgacem & Jay Parsons

Abstract

Under the Pasture, Rangeland, and Forage (PRF) insurance program, indemnities are triggered by precipitation shortfalls but may not align with actual forage yields. This study quantifies basis risk for 176 rangeland grid cells across the Nebraska Sandhills and Panhandle from 1988 to 2023 by linking the official rainfall index to remotely sensed forage production. Results show that rainfall–forage correlations range between 0.30 and 0.45 and exhibit marked spatial heterogeneity, with some grid cells displaying significantly stronger or weaker alignment. On average, On average, the complete-miss probability—defined as the likelihood that neither insured interval triggers when a forage loss occurs—is 12 percent, whereas the partial-miss probability—defined as the likelihood that only one interval triggers, leaving the producer only partially compensated—is 44 percent. However, these probabilities vary widely across the study region.

Higher coverage levels consistently lower the risk of receiving no indemnity but often amplify the likelihood of insufficient payouts. Nonetheless, in certain locations, pairing rainfall intervals that capture moisture during peak growth months can reduce complete misses below 10 percent. These findings underscore the importance of location-specific interval selection and the integration of finer-scale data to minimize basis risk, thereby enhancing the reliability of PRF as a drought management tool across ecologically diverse rangelands.

Keywords: index insurance, basis risk, forage production, rangeland management,

agricultural policy.

1 Introduction

Drought poses significant income and management risks for livestock producers who rely on grazing resources. The Pasture, Rangeland, Forage (PRF) insurance program is an index-based risk-management tool designed to partially offset these financial exposures. Under PRF, producers insure against low precipitation over selected two-month intervals, and payouts are triggered by rainfall shortfalls rather than actual hay or pasture yield losses (USDA RMA, 2006). Because these payouts depend solely on an objective, publicly reported index, PRF avoids costly field-level loss adjustment and largely eliminates the moral-hazard and adverse-selection problems that accompany traditional yield-based crop insurance. Federally subsidized premiums covering 51–59% of the premium cost further reduce participation expenses, helping insured acreage expand from 25 million acres in 2007 to nearly 290 million acres in 2023, while total liabilities rose from $326 million to $5.9 billion (RMA, 2023).

Despite this rapid expansion, extensive empirical evidence shows that the rainfall index can leave producers exposed to basis risk. When the index fails to capture actual forage conditions on the ground, insured ranchers can be left with uncompensated losses (Miranda & Farrin, 2012; Elabed et al., 2013) or receive windfall payments even without a real loss (Elabed & Carter, 2015; Vosper & Cecchi, 2023). These mismatches reduce the ability of the program to mitigate risk.

Two mechanisms generate these mismatches. Design risk arises when the rainfall index does not track forage outcomes, while measurement risk reflects the interpolation error if the rainfall index diverges from true local precipitation. The latter is usually minor; the rainfall index often correlates above 0.80 with gauge data in US studies (e.g. Maples et al., 2016), but the risk of design remains substantial, and it is the primary focus of the present study.

Empirical studies of design risk have tended to examine narrow geographic areas. For instance, Maples et al. (2016) find weak and sometimes negative rainfall–yield correlations in a single Oklahoma rye grass trial, while ShalekBriski et al. (2020) report similarly poor correlations at a nearby site. In grazing systems, Yu et al. (2019) estimate false negative probabilities (FNP) [1] of 26– 43% in three research ranches in the Great Plains and note that switching to on-site rain gauges would reduce risk by only 5–9 percentage points. Feuz et al. (2023) extend coverage to 12 monitoring sites on the central coast of California and document FNP of 48% when at least one interval fails to trigger, and 11% when both intervals miss.

However, complete elimination of the risk is unlikely, as forage conditions respond to local environmental factors, such as land quality and temperature, that may not be captured by rainfall index alone. In fact, the findings vary widely by region, which underscores the logistical difficulty of gathering direct forage measurements over an extended spatial scale.. Consistent field-based data are costly and time-consuming to obtain, which drives the need for remotely sensed proxies.

Building on this earlier work, which used the Normalized Difference Vegetation Index (NDVI)[2] as a proxy for forage production (Keller & Saitone, 2022), we use Rangeland Analysis Platform (RAP) data[3] [4], which integrates multi-sensor NDVI with a process-based production model to provide 30-m[5] spatial resolution, 16-day estimates of net primary production (NPP) partitioned by plant functional type and adjusted for temperature and fractional cover (Robinson et al., 2019; Allred et al., 2021; Jones et al., 2021; Allred et al., 2025). Although this remains an approximation of true forage availability, it provides a spatially comprehensive data set that enables large-scale analyses at the PRF grid level, an otherwise infeasible effort with traditional field-clipping methods.

This paper provides the first grid-level assessment of the risk of the PRF basis for a central Great Plains rangeland. Drawing on the Rangeland Analysis Platform (RAP), we align 1988–2023 perennial forb and grass biomass estimates with the USDA RMA rainfall index across 176 PRF eligible grids in the Nebraska Sandhills and Panhandle. This approach enables

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[1] The conditional probability that a forage shortfall occurs yet the insured rainfall intervals do not trigger an indemnity.

[2] NDVI is a dimensionless metric computed as $(\rho_{\text{NIR}} - \rho_{\text{red}})/(\rho_{\text{NIR}} + \rho_{\text{red}})$, where ρ_{NIR} and ρ_{red} denote surface reflectance in the near-infrared and red bands, respectively. Values range from -1 to $+1$, with higher values indicating greater green biomass and photosynthetic activity (Tucker, 1979).

[3] RAP is now maintained by USDA–ARS in partnership with the University of Montana and other federal agencies (USDA–ARS, 2023).

[4] For additional validation and management applications of RAP data, see e.g., Allred et al. (2021b), Jones et al. (2020), Li, Angerer & Wu (2022), and Uden et al. (2019).

[5] Each RAP pixel represents a 30-meter × 30-meter ground area.

us to (i) identify the two-month rainfall intervals that most closely track forage production and (ii) quantify both partial and complete false-negative probabilities within the standard coverage range. The resulting cell-level maps provide a reproducible baseline for evaluating whether existing PRF interval selection and weighting options can reduce basis risk and enhance drought protection for ranchers.

The remainder of this paper is organized as follows. Section 2 documents the construction of the PRF grid system and details the data sources used to build the Rainfall Index and the RAP-based Forage Index, Section 3 details the methodology for analyzing the rainfall-forage correlation and measuring the basis risk, Section 4 presents the empirical results, including rainfall–forage correlation patterns and basis-risk maps at the grid level, and Section 5 discusses the key findings, policy implications and directions for future research.

2 Data and Index Construction

To investigate these issues, we construct a balanced panel that pairs USDA–RMA Rainfall Index values with RAP forage index for each of the 176 PRF eligible grids in the Nebraska Sandhills and Panhandle during 1988–2023. Each grid–year record, therefore, contains a bimonthly Rainfall Index value and an annual forage index, yielding $176 \times 36 = 6{,}336$ observations, which we describe in detail below.

2.1 Study Area

The Pasture, Rangeland, and Forage (PRF) insurance program is administered with a nationwide grid, each cell measuring 0.25° of latitude by 0.25° of longitude ,approximately 17 miles north–south and 13 miles east–west at Nebraska's latitude.[6]

Each cell is assigned a unique Grid_ID, which the U.S. Department of Agriculture's Risk Management Agency (USDA–RMA) uses to calculate rainfall-index insurance indemnities.

To achieve spatial alignment between RAP forage data and PRF grids, we retrieved the four corner coordinates of each Nebraska PRF grid from the USDA - RMA Grid Locator API, converted those coordinates into 176 square polygons ($0.25^\circ \times 0.25^\circ$), merged them into

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[6] Rainfall Index Insurance Standards Handbook (RMAStandards, 2023)

a single shapefile and then used `sf` and `terra` in `R` to verify that each polygon matched the official grid specification before overlaying forage data.

Next, we extract annual perennial forb and grass (PFG) biomass estimates for each PRF grid cell from 1986 to 2023 from the Rangeland Analysis Platform (RAP) via the `rapr` R package (Brown, 2025).This procedure yields a spatially explicit time series of forage production for the same coverage units used by PRF.

Figure 1 illustrates Nebraska's full PRF grid in grey, highlighting our 176 study cells in a green gradient corresponding to their mean (1986–2023) PFG biomass. These 176 cells collectively account for the majority of Nebraska's perennial-forage production, mainly in Cherry, Holt, Custer, Knox, and Scotts Bluff counties (Nebraska Department of Agriculture, 2023).

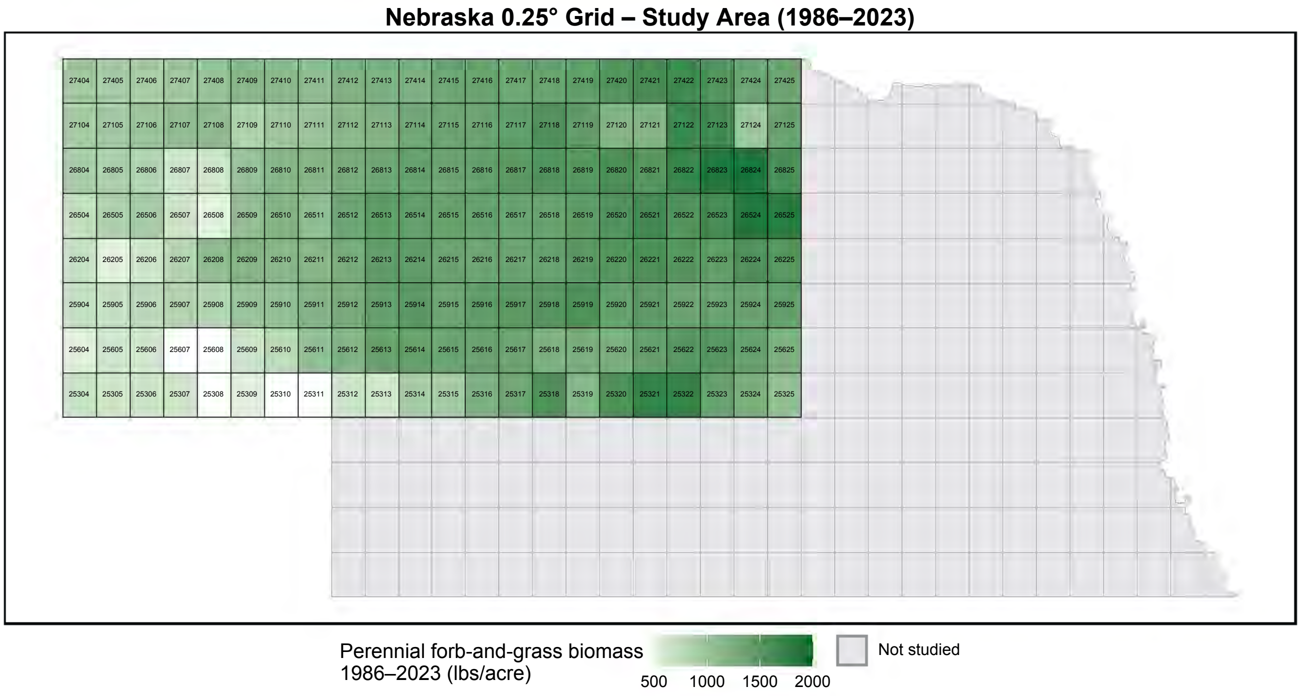

Figure 1: Nebraska PRF 0.25° grid. The green gradient shows the mean perennial forb-and-grass biomass (1986–2023) in the 176 study cells, while non-study cells (light grey) illustrate the complete PRF indexing framework. `Grid_ID` labels match the official USDA–RMA designations. Biomass data source: RAP v4.

2.2 Rainfall Index

Producers must finalize their PRF insurance decisions (e.g., coverage level, productivity factor, and interval selection) by the sales closing deadline of December 1 in the preceding calendar year (USDA RMA, 2006). Once coverage is purchased, it attaches on January 1 of the insured year, and indemnities are triggered by low precipitation in the insured intervals. Nationwide, PRF offers eleven standard two-month intervals spanning January–February through November–December. Producers must select at least two non-overlapping intervals. However, in Nebraska, winter precipitation generally arrives as snowfall, which does not necessarily translate into adequate soil moisture for early forage growth . Consequently, we exclude the January–February (Jan.Feb) interval from our analysis to avoid distorted precipitation measures. Moreover, late-season intervals (Sep.Oct, Oct.Nov, Nov.Dec) are omitted because perennial forage production in central and northern Great Plains rangelands typically slows considerably by early autumn (Smart et al., 2021). This leaves seven core intervals::

Feb–Mar, Mar–Apr, Apr–May, May–Jun, Jun–Jul, Jul–Aug, Aug–Sep.

From these seven intervals, we form all valid non-overlapping pairs [7] . Table 1 lists the resulting 15 pairs that producers could choose in Nebraska under our study assumptions (e.g., Feb.Mar with Apr.May, Feb.Mar with May.Jun, etc.).

The official Rainfall Index for each grid g, interval i, and year t is

$$RI_{g,i,t} \;=\; 100 \times \frac{\text{precipitation}_{g,i,t}}{\overline{\text{precipitation}}_{g,i,\,(t-2))}},$$

where $\overline{\text{precipitation}}_{g,i,\,(t-2))}$ is the long-term historical mean based on data from 1948 through $t-2$ (i.e., two years prior to the current year). The numerator $\text{precipitation}_{g,i,t}$ is the current precipitation (as measured by NOAA) in grid g and interval i for year t. These index values are published by RMA and cannot be altered by producers or insurers.

An indemnity is triggered for a chosen interval if the realized index falls below the elected

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[7] Throughout the analysis we assume that the producer splits the required 100 percent of liability evenly between the two chosen intervals (50 percent on each)

coverage level (for instance, $RI_{g,i,t} < 90$ if a 90% coverage was selected).

2.3 Forage Index

Instead of focusing on a precise measure of total biomass, we focus on whether a given year's forage production is below (or above) the grid's own long-term average. By comparing current conditions with historical norms, our forage index is constructed in the same manner as the rainfall index and is defined as

$$FI_{g,t} \; = \; 100 \times \frac{\text{biomass}_{g,t}}{\overline{\text{biomass}}_{g,t-2}},$$

where $\overline{\text{biomass}}_{g,t-2}$ is the average biomass in grid g from 1986 up to $t-2$.

A value of $FI_{g,t} = 100$ indicates that biomass in year t equals the grid's long-run mean through $t-2$; values below (above) 100 signal lower (higher) than normal forage production.

Having spatially aligned the Nebraska PRF grid system with NOAA precipitation data and RAP based forage estimates to enable basis risk estimation, we now turn to Section 3. There we discuss the conceptual rationale for examining the rainfall forage correlation and for defining partial and complete false-negative probabilities (FNP) as indicators of basis risk.

3 Methodology

Following Maples et al. (2016), a rancher's decision to purchase a PRF contract is treated as an expected-utility maximisation problem. Let $A \in \{0, 1\}$ denote the binary choice to enrol ($A = 1$) or not ($A = 0$) on grid g in year t. Conditional profit is defined as

$$\pi_{g,t}(A) = P\,Y_{g,t} - \mathbf{r}'\mathbf{z}_g + A\,[k_{g,t} - \alpha_g], \tag{1}$$

where P is the forage price, $Y_{g,t}$ the realised biomass, $\mathbf{r}'\mathbf{z}_g$ the cost of non-forage inputs, $k_{g,t}$ the indemnity per acre triggered by the rainfall-index pair $(RI_{g,k,t}, RI_{g,\ell,t})$ at coverage level C, and α_g the producer-paid portion of the premium net of federal subsidy. Given a concave, increasing utility function $U(\cdot)$, the producer chooses

$$A^* = \arg\max_{A\in\{0,1\}} \int U(\pi_{g,t}(A))\ f_g\big(RI_{g,k,t}, RI_{g,\ell,t}, Y_{g,t}\big)\, d\theta, \tag{2}$$

where $f_g(\cdot)$ is the joint density of the two rainfall indices and biomass.

Because the indemnity depends solely on the selected rainfall indices, the effectiveness of PRF as a hedge is governed by the strength of the statistical relationship between those indices and forage production. To quantify this relationship, we computes the canonical correlation $R_{c,g}(k,\ell)$ between the two-interval rainfall vector $\big(RI_{g,k,t}, RI_{g,\ell,t}\big)$ and the forage index $FI_{g,t}$. A larger $R_{c,g}(k,\ell)$ indicates tighter alignment of rainfall signals with biomass outcomes and therefore a greater potential welfare gain from enrolment, particularly when premiums are subsidised.

3.1 Basis risk estimation

Basis risk is quantified as the probability that a forage loss is not fully compensated by the rainfall intervals. We follow the definitions used by Elabed et al. (2013), Yu et al. (2019), and Keller & Saitone (2022). Let $C \in \{0.70, \ldots, 0.90\}$ denote the coverage level , $FI_{g,t}$ the forage index, and $RI_{g,k,t}, RI_{g,\ell,t}$ the rainfall indices for the insured intervals k and ℓ. Conditional on a forage loss ($FI_{g,t} < C$), the two relevant false-negative probabilities are

$$\mathrm{FNP}_p(k,\ell;g,C) = \Pr\big[\,RI_{g,k,t} < C,\ RI_{g,\ell,t} \geq C\ \text{ or }\ RI_{g,k,t} \geq C,\ RI_{g,\ell,t} < C\ \big|\ FI_{g,t} < C\big], \tag{3}$$

$$\mathrm{FNP}_c(k,\ell;g,C) = \Pr\big[\,RI_{g,k,t} \geq C,\ RI_{g,\ell,t} \geq C\ \big|\ FI_{g,t} < C\big]. \tag{4}$$

FNP_p is the probability of a *partial miss* (exactly one interval triggers, yielding an indemnity), whereas FNP_c is the probability of a *complete miss* (neither interval triggers, yielding no indemnity).

4 Results

4.1 Rainfall–Forage Correlation

We begin by assessing how closely the rainfall index in each two-month interval pair correlates with the forage index that we created in (Section 2.3). Table 1 summarizes the canonical R statistics (mean, standard deviation, minimum, and maximum) for the 15 non-overlapping pairs in Nebraska PRF grids. Overall, May.Jun paired with Jul.Aug ranks among the highest mean correlations (0.450), followed very closely by Apr.May + Jun.Jul ($\bar{R} = 0.449$) and Mar.Apr + May.Jun ($\bar{R} = 0.431$).

Table 1: Canonical–R summary statistics (across all 176 PRF grids) for the 15 non-overlapping two-month rainfall-interval pairs

k	**l**	**Mean**	**SD**	**Min**	**Max**
Feb.Mar	Apr.May	0.349	0.120	0.095	0.629
Feb.Mar	May.Jun	0.427	0.131	0.065	0.695
Feb.Mar	Jun.Jul	0.363	0.161	0.021	0.669
Feb.Mar	Jul.Aug	0.284	0.139	0.009	0.687
Feb.Mar	Aug.Sep	0.188	0.110	0.013	0.506
Mar.Apr	May.Jun	0.431	0.130	0.015	0.737
Mar.Apr	Jun.Jul	0.376	0.161	0.021	0.688
Mar.Apr	Jul.Aug	0.306	0.144	0.033	0.697
Mar.Apr	Aug.Sep	0.212	0.113	0.017	0.473
Apr.May	Jun.Jul	0.449	0.152	0.078	0.723
Apr.May	Jul.Aug	0.412	0.143	0.099	0.726
Apr.May	Aug.Sep	0.340	0.124	0.016	0.610
May.Jun	Jul.Aug	0.450	0.141	0.073	0.721
May.Jun	Aug.Sep	0.419	0.135	0.065	0.692
Jun.Jul	Aug.Sep	0.355	0.166	0.006	0.685

To visualize the spatial heterogeneity in these correlations, Figure 2 presents two maps. Panel A (left) plots the canonical R for the May.Jun + Jul.Aug combination in each grid, while Panel B (right) displays the mean R across all 15 pairs. Darker shading indicates stronger alignment between rainfall and forage production. Notably, approximately one-third of the grids show a strong rainfall–forage link ($R > 0.50$, 53 grids), just over one-quarter fall below the weak threshold of $R < 0.30$ (48 grids), 13 % lie in the low–moderate band $0.30 \leq R < 0.40$ (23 grids), and the remaining 30 % occupy the mid-range $0.40 \leq R \leq 0.50$

(52 grids).

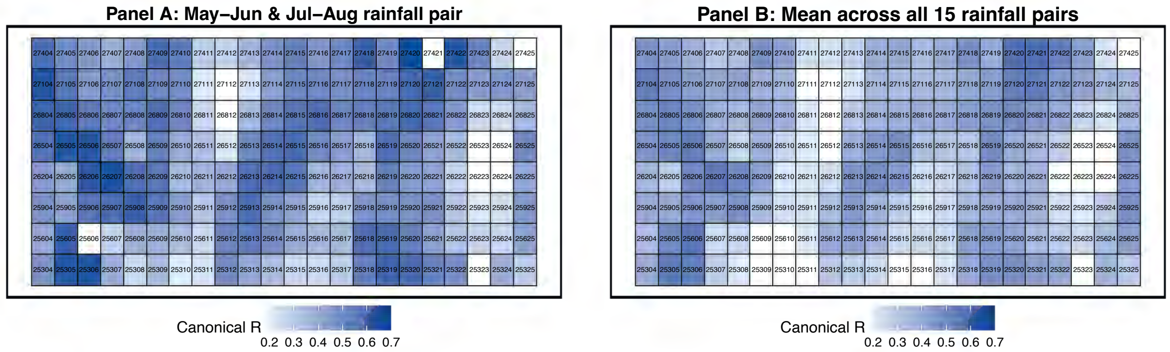

Figure 2: Rainfall–forage canonical correlations across Nebraska PRF grids (1988–2023). **Panel A** (left) plots the canonical R for the `May.Jun` & `Jul.Aug` rainfall-interval pair. **Panel B** (right) shows the mean canonical R across all 15 non-overlapping rainfall-interval pairs. Darker shading indicates a stronger linear relationship between rainfall and forage production at the grid level.

4.2 Basis-Risk results

Although strong rainfall–forage correlation suggests that certain intervals May.Jun + Jul.Aug, for instance) might better capture forage losses, the ultimate measure of PRF effectiveness is whether producers are compensated when actual forage shortfalls occur. Table 2 presents false-negative probability (FNP) values for each coverage level (70–90%) and each two-month interval pair, aggregating all 176 PRF grids. The first value in each cell (FNP_p) corresponds to partial-miss events (exactly one interval triggered), while the bracketed value (FNP_p) denotes complete-miss events (neither interval triggered). Higher percentages indicate a greater likelihood of uncompensated losses.

Several notable patterns emerge. First, higher coverage selections (e.g., 90%) tend to reduce complete misses (FNP_c) in many interval pairs but can simultaneously increase partial-miss probabilities (FNP_p). Second, certain pairs such as May.Jun + Jul.Aug often yield lower complete-miss rates than, for instance, Feb.Mar + Jul.Aug, reflecting the importance of capturing rainfall in active growth months. Nevertheless, basis risk persists in all configurations: for instance, even at 90% coverage, the May.Jun + Aug.Sep combination shows

Table 2: Conditional false-negative probabilities (%) averaged across all 176 PRF grids. For each two-month rainfall-interval pair ($\mathbf{k}$, $\mathbf{l}$) and coverage level, the first entry in a cell is the *partial-miss* probability (FNP_p), while the bracketed entry is the *complete-miss* probability [FNP_c].

		Coverage level				
k	**l**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**
		FNP_p [FNP_c]	FNP_p [FNP_c]	FNP_p [FNP_c]	FNP_p [FNP_c]	FNP_p [FNP_c]
Feb.Mar	Apr.May	30 [26]	33 [22]	33 [21]	39 [17]	42 [15]
Feb.Mar	May.Jun	33 [21]	34 [16]	33 [15]	36 [13]	40 [10]
Feb.Mar	Jun.Jul	39 [17]	43 [14]	39 [13]	39 [12]	40 [8]
Feb.Mar	Jul.Aug	55 [30]	52 [23]	52 [15]	52 [13]	46 [12]
Feb.Mar	Aug.Sep	47 [44]	50 [37]	50 [32]	50 [29]	50 [24]
Mar.Apr	May.Jun	16 [25]	20 [21]	23 [19]	28 [17]	33 [15]
Mar.Apr	Jun.Jul	24 [20]	30 [16]	30 [14]	34 [13]	35 [11]
Mar.Apr	Jul.Aug	60 [23]	57 [18]	48 [16]	47 [15]	43 [15]
Mar.Apr	Aug.Sep	59 [34]	56 [27]	54 [25]	52 [22]	50 [22]
Apr.May	Jun.Jul	20 [19]	25 [17]	29 [16]	29 [14]	33 [12]
Apr.May	Jul.Aug	58 [21]	50 [19]	43 [18]	38 [18]	37 [16]
Apr.May	Aug.Sep	62 [29]	60 [27]	63 [24]	60 [22]	55 [21]
May.Jun	Jul.Aug	67 [12]	67 [9]	62 [8]	62 [8]	53 [6]
May.Jun	Aug.Sep	71 [21]	71 [19]	72 [15]	70 [14]	65 [14]
Jun.Jul	Aug.Sep	73 [19]	66 [21]	62 [19]	60 [17]	58 [12]

a partial-miss probability around 65% and a complete-miss probability near 14%. This indicates that many forage loss events, in the pooled sense, remain uncompensated.

Having summarized pooled basis-risk outcomes by coverage level and interval in Table 2, we next explore how basis risk varies spatially with each grid . We focus on the two interval pairs that exhibit the lowest basis risk at the 90% coverage level: May.Jun + Jul.Aug (FNP_c = 6%) and Feb.Mar + Jun.Jul (FNP_c = 8%). Figures 3 and 4 therefore present two-panel maps for these configurations, each showing (left) the complete-miss probability (FNP_c) and (right) the partial-miss probability (FNP_p). Darker shading denotes lower basis risk, whereas lighter areas indicate a higher likelihood of uncompensated losses.

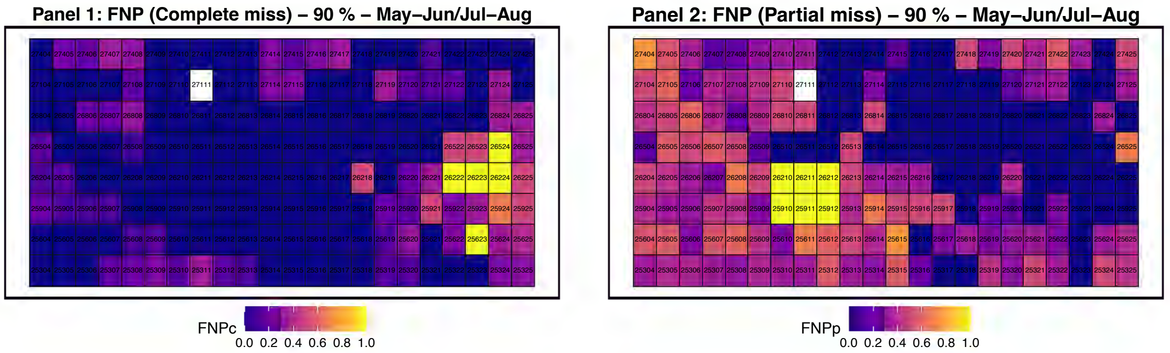

Figure 3: Grid-level basis risk at 90% coverage for intervals `May.Jun` and `Jul.Aug`. Left: complete-miss FNP (FNP_c). Right: partial-miss FNP (FNP_p).

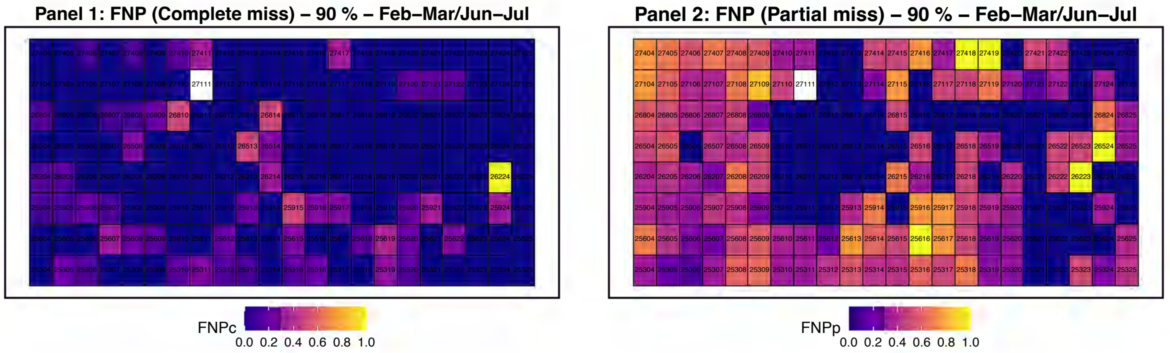

Figure 4: Grid-level basis risk at 90% coverage for intervals `Feb.Mar` and `Jun.Jul`. Left: FNP_c. Right: FNP_p.

Comparing Figures 3 and 4 highlights how the choice of interval pair influences both the type and location of basis risk. At a 90% coverage level, the May.Jun–Jul.Aug pair (Figure 3) exhibits only moderate complete-miss basis risk (FNP_c), averaging 0.12. The highest FNP_c values cluster along the eastern Sandhills and the Lower Platte Valley (e.g., grids 26224 and 26524). By contrast, partial-miss basis risk (FNP_p) is pronounced in a south-central belt spanning grids 25920–25925 and 26218–26223. Sixteen grids exceed the 0.60 threshold for FNP_p, yet in 108 grids complete misses do not occur at all ($\mathrm{FNP}_c = 0$).

Switching to the early-season Feb.Mar–Jun.Jul pair (Figure 4) nearly eliminates complete misses: the mean FNP_c falls to 0.07, and $\mathrm{FNP}_c = 0$ in 124 grids. However, this improvement is offset by higher partial-miss risk. The mean FNP_p rises to 0.32, with 30 grids—forming a diagonal swath from the north-central Sandhills through Custer County into the River Valley—exceeding 0.60. This trade-off echoes Table 2: earlier rainfall intervals markedly reduce the chance of receiving no indemnity, but increase the likelihood that only one interval triggers, leaving part of the loss uncompensated.

All Coverage and Interval Pairs Averaged

To provide a broader perspective on where PRF coverage might be misaligned most often, Figure 5 collapses every coverage level (70–90 %) and all fifteen interval pairs into a single statewide view of basis risk. Averaged across these design choices, complete-miss risk remains limited: the mean value is $\bar{\text{FNP}}_c = 0.12$, about one grid in five records $\text{FNP}_c = 0$, and fewer than 5 % of grids rise above $\text{FNP}_c > 0.4$. Partial-miss risk is naturally higher $\bar{\text{FNP}}_p = 0.44$, yet only a small share of grids ($\approx$ 5 %) exceed $\text{FNP}_p > 0.6$ and just one grid falls to zero. In short, most of Nebraska's PRF cells exhibit low likelihood of a *total* failure to trigger, but a moderate chance that only one of the two intervals will respond when forage losses occur.

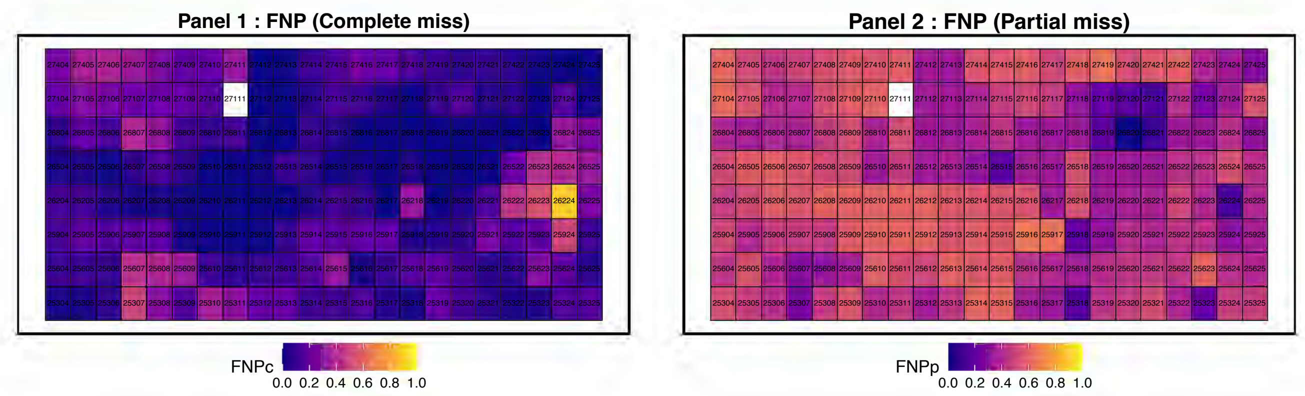

Figure 5: Grid-level basis risk averaged across all interval pairs and coverage levels (70–90%). Panel 1 (left) maps FNP_c (complete miss); Panel 2 (right) maps FNP_p (partial miss).

5 Discussion and Conclusion

Nebraska PRF grids show a substantially lower probability of complete misses during a forage shortfall, aligning closely with (Feuz et al., 2023) yet remaining below the levels reported by other studies. Specifically, the average complete-miss probability across coverage levels and interval pairs is approximately 0.12, meaning producers face about a one in eight chance of receiving no indemnity during a forage shortfall. This outcome is below the 25–47 percent range observed for California at the 85 percent coverage level (Keller & Saitone, 2022) and below the 26–43 percent probabilities reported at experimental Great Plains ranches (Yu et al., 2019).

Partial-miss probability, averaging 0.44, a level broadly consistent with previous empirical findings. Selecting adjacent intervals (for example, May–June and July–August) helps avoid a total failure to trigger, but it leads to a greater likelihood that only one interval will pay when losses occur. Conversely, pairing temporally distant intervals can reduce partial misses but often increases the frequency of complete misses.

Relative to site-level rainfall–yield studies (Maples et al., 2016; ShalekBriski et al., 2020), the use of satellite-derived biomass and spatially aggregated data in this article improves the measured rainfall–forage relationship (correlations reach 0.45). However, even the best intervals fall short of the 0.60 threshold that some researchers see as ideal for robust accuracy (Woodard & Garcia, 2008).

This gap relates more to informational constraints than to any fundamental design flaw. Producers in Nebraska already have considerable discretion in interval selection, they can distribute total coverage across two to six non-overlapping two-month intervals, allocating between 10 and 60 percent of insured value per interval. Improving the outcomes hinges more on refining these interval choices than modifying the coverage structure itself. One step could be a decision support tool that overlay the Rainfall Index values with RAP-based forage anomalies to identify interval combinations that minimize partial and complete misses for each grid. Another could be a blended trigger option that combines forage signals from RAP with rainfall, reducing basis risk in conditions where precipitation alone poorly captures soil-moisture and temperature effects. Finally, behavioral nudges that highlight grids and interval sets that exhibit strong past performance may guide producers to lower risk coverage weights, enhancing the existing program.

Several caveats remain. Errors in satellite estimates, cloud interference, and model assumptions can introduce measurement noise. The focus on the Sandhills and Panhandle grids may limit generalizations to regions with different precipitation patterns or rangeland conditions. Future research could build on these findings by examining the interplay of climate variability and rangeland productivity, particularly focusing on persistent drought conditions, shifting precipitation timing, and extreme temperatures. Integrating advanced satellite data with targeted on-the-ground measurements would help reveal localized drivers of forage loss that rainfall alone may not capture. Analyzing actual producer decisions ,and resulting financial outcomes under various coverage-level and interval-selection strategies could further clarify how well the program functions across heterogeneous production systems. These efforts would ultimately strengthen the empirical foundation to improve PRF design, mitigate basis risk, and improve drought resilience for Nebraska's rangelands and beyond.

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