Upstream Advantage: The Economic Value of Water Security Under Riparian Rights in Eastern U.S. Agriculture

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Selected paper prepared for presentation at the 2025 AAEA & WAEA Joint Annual Meeting in Denver, CO; July 27-29, 2025

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Abstract

This paper investigates whether counties positioned upstream in river networks—those physically first in line for stream flow under riparian water rights—experience greater resilience in agricultural land values and crop productivity during drought. Using county-level panel data from 1950 to 2022 across the Eastern United States, we combine agricultural outcomes with geospatial measures of stream proximity and groundwater access, and evaluate their interaction with standardized precipitation anomalies. Benchmark specifications show that groundwater access consistently enhances farmland value and yields, while stream access yields more nuanced patterns: downstream access is associated with higher farmland values under normal conditions, whereas upstream access is negatively associated with corn yields on average and shows limited benefits under extreme drought. However, upstream counties exhibit higher farmland values under prolonged dryness and greater corn yield gains during wet years—benefits not observed for soybean yields or in downstream areas. These results suggest that upstream proximity offers conditional advantages tied to crop water sensitivity and climate regime. As drought risk intensifies, this study provides the first systematic empirical evidence on how spatial positioning within stream networks under riparian doctrine shapes the economic geography of agricultural resilience.

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Introduction

Water rights in the United States follow two primary legal doctrines shaped by geography and history. Riparian rights, inherited from English common law, dominate in the Eastern U.S., where water has historically been abundant. Under the riparian doctrine, landowners adjacent to a watercourse have usufructuary rights to reasonable use, subject to correlative reductions in times of shortage (Dellapenna, 2004; Hu and Eheart, 2014). These rights are tied to the land and generally cannot be transferred separately. In contrast, the Western U.S. operates under the prior appropriation doctrine—a system developed in the 19th century to accommodate water scarcity. Under this framework, the first user to claim and beneficially use water has seniority over later users, with rights often quantified and severable from the land (Leonard and Libecap, 2019). This distinction has profound implications for economic incentives, water allocation efficiency, and land values.

While riparian rights were historically sufficient in the water-abundant East, recent decades have brought increased frequency and severity of droughts, raising concerns about the adequacy of traditional doctrines. In response, several eastern states have adopted regulated riparianism, replacing vague standards of "reasonable use" with permit-based withdrawal limits (Dellapenna, 2004). Yet in many regions, informal norms and de facto spatial priorities persist, particularly during drought. For example, courts have often interpreted upstream users as having physical priority over downstream users, despite no formal allocation rule (Hu and Eheart, 2014). To evaluate whether this spatial positioning translates into economic advantages, we examine whether counties located closer to stream headwaters experience greater resilience in agricultural land values and crop productivity during drought conditions.

Empirical research on the economic implications of riparian water rights has been relatively limited, partly due to historically abundant water and minimal binding constraints. However, emerging evidence shows that even under riparian or permit-based regimes, water scarcity can confer substantial value to secure access. In Georgia, for instance, a moratorium on new irrigation permits in certain watersheds led to a 30% increase in farmland prices for properties with grandfathered water access (Petrie and Taylor, 2007). This underscores the broader principle: water security is economically valuable, especially under increasing climate stress.

A growing body of work has emphasized the economic resilience conferred by secure water access. Smith and Edwards (2021) show that in the arid West, the development of irrigation infrastructure and aquifer pumping has significantly buffered crop yields against drought. In contrast, in the Eastern U.S., where irrigation is less prevalent and riparian law dominates, corn and soybean yields have historically declined during drought regardless of proximity to water bodies. Relatedly, Cooley and Smith (2022) document that in Illinois, irrigation has been adopted primarily as a drought insurance mechanism, delivering yield stability in dry years rather than higher average productivity.

These findings highlight the economic value of water security and suggest that even spatial or de facto priority access—such as being located upstream—may matter when flows become constrained. Under riparian law, upstream users are physically situated to divert water first, creating a potential advantage in times of drought.

While a large body of economic research has examined the role of prior appropriation rights in structuring agricultural investment, irrigation infrastructure, and land allocation in the West (Leonard and Libecap, 2019; Cobourn, Ojha, and Wetzstein, 2022; Ward and Hrozencik, 2025), the Eastern system of riparian rights has received less empirical scrutiny. Historically, the East has benefited from relatively abundant precipitation, and courts operating under riparian law have generally presumed proportional sharing of cutbacks during drought (Hu and Eheart, 2014; Dellapenna, 2004). Yet as drought frequency and intensity increase—particularly in recent decades (Keellings and Engström, 2019; Leeper, Wood, and McCabe, 2022)—the adequacy of traditional riparian allocation is increasingly in question. Some eastern states have introduced regulated riparianism to clarify withdrawal limits, but in many areas, informal or spatial norms of priority persist.

This paper provides the first systematic empirical analysis of whether upstream counties—those situated closer to stream headwaters—experience greater resilience in agricultural outcomes under drought conditions in the Eastern United States. By combining hydrological, climatic, and agricultural data, we assess whether spatial proximity to water translates into economic advantage, and

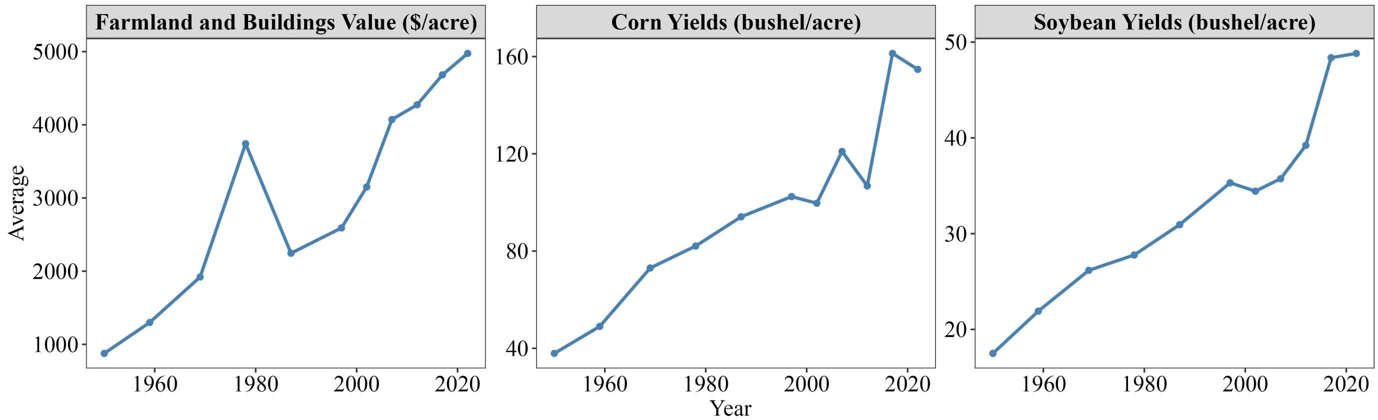

Figure 1: Trends in farmland and building values, crop yields (corn and soybean) from 1950 to 2022.

under what conditions that advantage is most pronounced.

Data

To investigate how stream position shapes drought resilience under riparian water rights, we compile a panel dataset of county-level agricultural, climatic, and geographic characteristics for the Eastern United States from 1950 to 2022. Observations are spaced at five-year intervals, consistent with the timing of the Census of Agriculture.

Agricultural Outcomes

Agricultural data are drawn from the U.S. Census of Agriculture. The dataset, digitized by Haines, Fishback, and Rhode (2018) for the period 1940–2012, is supplemented with 2017 and 2022 data from USDA Quick Stats. The primary outcome variables include (1) the natural log of farmland and buildings value per acre, and (2) crop yields for corn and soybeans, measured in bushels per acre. Farmland value serves as an indicator of long-term expectations and capitalized exposure to drought risk, while crop yields reflect more immediate production responses to weather variation.

Figure 1 presents the average trends in farmland and buildings value and crop yields for corn and soybeans over time. Farmland value rose markedly over the study period, increasing from below

$1,000 per acre in 1950 to over $5,000 by 2022. This growth was not linear—sharp appreciation occurred during the 1970s and again after 2000, while the 1980s saw a pronounced dip, consistent with the broader farm crisis and collapse in land prices during that decade. Corn yields also show substantial gains, rising from about 40 bushels per acre in 1950 to over 170 in recent years. The growth trajectory accelerated after 1990, reflecting technological improvements such as hybrid seeds, better nutrient management, and irrigation expansion. Soybean yields followed a similar upward pattern, increasing from under 20 bushels per acre in the 1950s to nearly 50 today, albeit with slightly more variation. Together, these trends underscore the rising productivity of Eastern U.S. agriculture and suggest that both land markets and crop performance have responded to evolving climate pressures, technological change, and underlying water access conditions.

Stream Proximity and Groundwater Access

To capture differences in surface water access, we use the National Hydrography Dataset (NHD) to compute the share of each county's land area located within 500 meters of mapped stream segments, classified by Strahler stream order. Two continuous indicators are constructed: the percent upstream area, defined as the share of land near third-order streams, and the percent downstream area, defined as the share near streams of order six or higher. This classification reflects both spatial position and stream size—third-order streams tend to be smaller headwater tributaries, while sixth-order and higher streams correspond to larger rivers with higher flow volumes. These proximity-based measures serve as proxies for how water access is shaped by geography under riparian rights. Counties with greater upstream area are positioned closer to the origin of streamflow and are therefore presumed to receive water earlier in the flow sequence. In contrast, downstream counties are adjacent to larger rivers but are located farther from the source and thus depend on upstream availability. This distinction is central to understanding how access priority may translate into drought resilience.

Figure 2 displays the spatial distribution of upstream and downstream buffer shares across the study region. Upstream access is widespread and evenly distributed, whereas downstream access clusters along major river corridors such as the Mississippi, Ohio, and their tributaries.

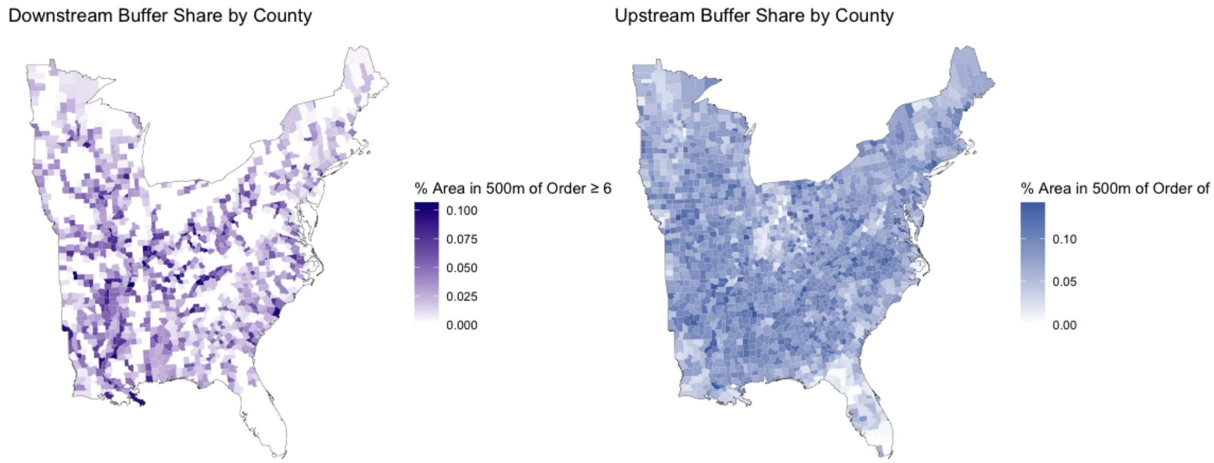

Figure 2: County-Level Stream Access Based on Proximity to Stream Order. The left panel shows the share of land area within 500 meters of streams of order six or higher, representing downstream access. The right panel displays the share of each county's land area located within 500 meters of third-order streams, representing upstream access.

We also include a continuous measure of groundwater access using the U.S. Geological Survey's principal aquifer boundaries. Specifically, we calculate the percentage of each county's land area that overlays a mapped aquifer. This variable is used in parallel with surface water indicator to evaluate how different sources of water access influence the effect of drought on agricultural land value and productivity under riparian water rights.

Climate and Soil Conditions

Climate data are obtained from the PRISM Climate Group and include annual average precipitation and average temperature from 1920 onward. For each county, we calculate the long-run historical mean and standard deviation of average precipitation to construct standardized precipitation anomalies. These anomalies are used to define drought bins for the yield regressions and, in the case of the farmland value model, averaged over a ten-year trailing window to capture longer-term climate stress.Soil characteristics are sourced from the USDA's SSURGO and STATSGO databases. These variables account for baseline differences in soil fertility and moisture retention, which may confound the effects of water access or drought exposure on agricultural performance.

Research Methodology

This study investigates whether upstream counties—those positioned closer to stream headwaters—experience greater resilience in agricultural land values and crop productivity during periods of drought. Under riparian water rights, proximity to the source can effectively determine priority access, especially when streamflow is diminished. To examine this question empirically, we combine panel data on farmland values and crop yields with spatial hydrology and climate data, focusing exclusively on the post-1950 period when irrigation infrastructure and legal water institutions had become broadly established across the Eastern United States.

Before introducing precipitation shocks, we begin with a benchmark panel specification that estimates the relationship between agricultural outcomes and access to water sources under average climatic conditions. The model is defined as:

$$Y_{it} = \sum_k \beta_k \cdot W_{k,i} + \mathbf{X}_i' + \alpha_s + \tau_t + \varepsilon_{it} \tag{1}$$

Here, Y_{it} denotes the outcome of interest for county i in year t: either the natural log of farmland and buildings value per acre (observed only in 2022), corn yield, or soybean yield. The key explanatory variables, $W_{k,i}$, are the share of each county's land area within 500 meters of third-order (upstream) streams, sixth-order and higher (downstream) streams, and the share overlapping mapped aquifers. The vector $\mathbf{X}_i$ includes soil characteristics. All regressions include year fixed effects τ_t, state fixed effects α_s, and standard errors clustered at the county level. This benchmark model provides a reference point for assessing whether surface water access, either upstream or downstream is systematically associated with agricultural performance across counties, independent of short-term precipitation variation.

Precipitation Shocks

To evaluate how the effect of water access varies with climate anomalies, we incorporate county-level precipitation shocks into the empirical framework. We follow the approach of Smith and

Edwards (2021), who discretize standardized precipitation anomalies into bins to capture nonlinear responses to weather variation. Specifically, for each county and year, we compute a standardized precipitation anomaly defined as the difference between that year's growing-season precipitation and the county-specific long-run mean, divided by the county-specific standard deviation (computed from 1920 to 2022). This z-score facilitates standardized comparisons across counties with different rainfall baselines.

We categorize these standardized precipitation anomalies into five mutally exclusive bins: *significantly wet* years ($z \leq -1.5$), *moderately wet* years ($-1.5 < z \leq -0.5$), *normal* years ($-0.5 < z < 0.5$), *moderately dry* years ($0.5 \leq z < 1.5$), and *significantly dry* years ($z \geq 1.5$). Normal years serve as the omitted reference category. These precipitation bins are then interacted with the water access variables to assess whether surface or groundwater availability moderates the effects of precipitation shocks.

The full econometric specification is as follows:

$$Y_{it} = \sum_{k} \beta_k \cdot W_{k,i} + \sum_{j \neq 0} \gamma_j \cdot D_{j,it} + \sum_{j \neq 0} \sum_{k} \theta_{j,k} \cdot (W_{k,i} \times D_{j,it}) + \mathbf{X}_i' + g(temp_{it}) + \alpha_s + \tau_t + \varepsilon_{it} \quad (2)$$

In this equation, $D_{j,it}$ represents binary indicators for each precipitation bin j, where $j \neq 0$ excludes the normal bin. The interaction terms $W_{k,i} \times D_{j,it}$ capture how the effect of precipitation shocks varies with county-level water access. The interaction coefficients $\theta_{j,k}$ are the main parameters of interest, indicating whether the presence of upstream, downstream, or groundwater access alters a county's vulnerability or resilience to precipitation extremes.

In the farmland value model, the precipitation shock variable is computed as a ten-year trailing moving average of standardized precipitation anomalies, capturing longer-run drought exposure that may influence land markets. In contrast, the crop yield models use annual precipitation shocks to reflect short-run production risks. The temperature variable enters as a third-order polynomial $g(temp_{it})$ to flexibly capture its nonlinear influence on yields. All regressions maintain year and state fixed effects and cluster standard errors at the county level.

Table 1: Estimated Effects of Water Access on Farmland Value and Crop Yields

	log(Farmland and buildings value)	log(Corn yield)	log(Soybean yield)
Upstream Area Share	-0.44 (0.30)	-0.43^{**} (0.16)	-0.02 (0.23)
Downstream Area Share	0.64^{*} (0.31)	-0.04 (0.16)	-0.08 (0.22)
Aquifer Share	0.10^{***} (0.03)	0.07^{***} (0.01)	0.07^{***} (0.02)
Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
Observations	20,594	18,354	10,490
R^2	0.7980	0.8477	0.7747
Within R^2	0.0426	0.0162	0.0073

Notes: Each column presents results from a fixed effects regression based on equation 1 with the specified dependent variable. Control variables include county-level soil characteristics. All models include state and year fixed effects. Standard errors clustered at the county level (FIPS) are reported in parentheses. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$.

By estimating this model, we directly test whether counties with greater upstream access experience smaller yield or land value losses during dry years. If riparian rights translate into water security, we would expect the coefficients on upstream interactions in dry conditions to be positive. Conversely, if downstream or aquifer access fails to offset the impact of precipitation shocks, these interaction terms would remain small or statistically insignificant.

Results and Discussion

We first examine the average relationship between water access and agricultural outcomes, independent of precipitation variation. Table 1 reports the estimated effects of a one percentage point increase in upstream area share, downstream area share, and aquifer coverage on farmland value and crop yields. Counties with greater aquifer coverage show consistently positive and statistically significant associations with all three outcomes. A one percentage point increase in aquifer share is associated with a 0.096% increase in farmland value, a 0.074% increase in corn yield, and a 0.071% increase in soybean yield. This suggests that groundwater presence is generally beneficial for agricultural productivity, even in the absence of drought.

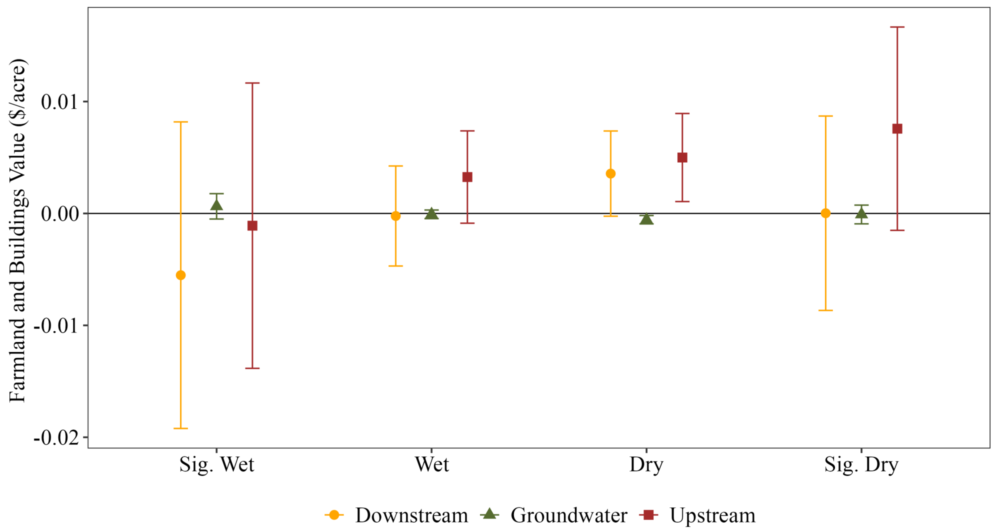

Figure 3: Farmland Value Response to Precipitation Conditions by Water Access Type. Each point represents the marginal effect of a one percentage point increase in water access (e.g., percent upstream area) based on equation 2, and vertical bars indicate 90% confidence intervals.

In contrast, stream access shows more heterogeneous results. Greater downstream area share is positively associated with farmland and buildings value at the 10% significance level, but has no significant effect on corn or soybean yields. Greater upstream area share is negatively associated with corn yields, and marginally negative but statistically insignificant for land value and soybean yield. These benchmark specification results suggest that, on average, irrespective of annual precipitation variation, groundwater access is more systematically beneficial than surface water access, and that being upstream may be correlated with lower corn productivity. This may reflect the fact that corn has greater water requirements than soybean and is more sensitive to disruptions in water availability. Counties with limited surface water access—despite being upstream—may be less able to support optimal corn growth if infrastructure or flows are insufficient. Soybeans, in contrast, may not show strong yield responses to location within the stream network due to their comparatively lower water demand and greater tolerance for transient water stress.

Figure 3 turns to the interactive effects of water access and drought exposure on farmland value. Here, we find that counties with greater upstream stream area tend to show modestly positive responses under persistent drought exposure. A one percentage point increase in upstream area

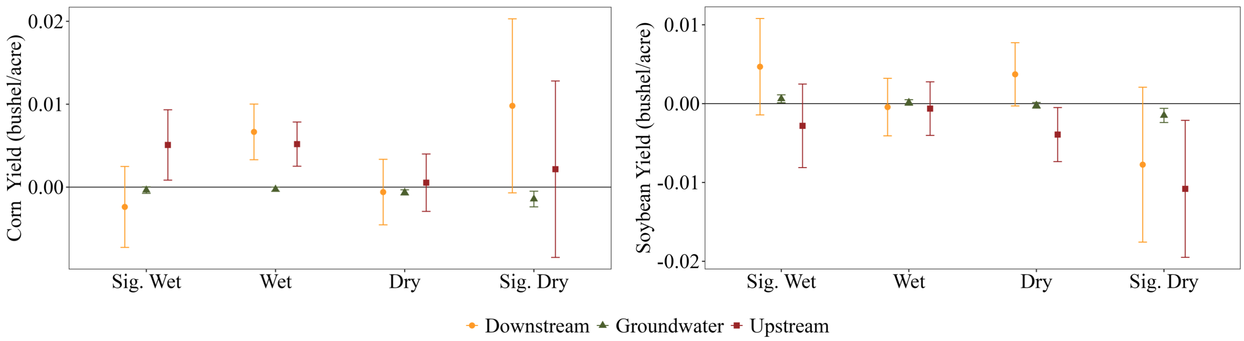

Figure 4: Crop Yield Response to Precipitation Conditions by Water Access Type. Each panel plots estimated effects of a one percentage point increase in water access on corn yields (left panel) and soybean yields (right panel) based on equation 2, with vertical bars representing 90% confidence intervals.

share is associated with approximately a 0.5% increase in farmland value in counties that experienced more frequent dry years over the previous decade—a statistically significant effect. However, this effect does not hold under more extreme drought conditions, where estimates are no longer statistically distinguishable from zero. Downstream area share continues to exhibit no statistically meaningful relationship, while groundwater access also shows no consistent effect. These findings suggest that the long-term economic value of upstream location is limited and conditional: it may confer some advantage under prolonged but moderate dryness, yet offers limited protection under more severe water stress.

Figure 4 displays the estimated effects of drought bins on corn and soybean yields, interacted with water access measures. For corn, the clearest positive effects are observed in wetter years. A one percentage point increase in upstream area share is associated with a 0.5% increase in corn yield in both wet and significantly wet years. These effects are statistically significant and indicate that counties with greater upstream access may be better able to capture the benefits of excess precipitation. Downstream stream access also appears beneficial in wet years, but its effect in significantly wet conditions is smaller and statistically insignificant. This may reflect increased runoff accumulation or local saturation in downstream areas, which can pose agronomic risks under extreme wetness. Groundwater access shows weak or null effects across drought bins and does not appear to buffer corn yields during dry conditions.

Soybean yields do not display the same structure. Neither upstream nor downstream area share is significantly associated with yield in any drought bin. Although upstream proximity is negatively associated with soybean yields during dry and significantly dry years, these estimates are not statistically significant. Similarly, while groundwater access shows a negative and significant effect in the significantly dry bin, its magnitude is modest. These results suggest that neither form of surface water access provides meaningful drought resilience for soybean production, and that even groundwater access may be insufficient to offset extreme dryness in this context. This pattern is because corn is a more water-intensive crop than soybean and is particularly sensitive to moisture availability. In contrast, soybeans are relatively more drought-tolerant and capable of recovering from short-term stress. As a result, differences in water access are more likely to translate into yield advantages for corn, particularly in wet years, than for soybeans in dry years.

These results reveal a key spatial asymmetry in the structure of water access and its economic implications. Downstream counties generally lie along larger rivers with greater total flow volume, which may help explain their higher average farmland values in the base model. In contrast, upstream counties are presumed to enjoy a locational advantage under riparian rights—being physically first in line for access to flowing water. While this advantage does not appear to translate into higher average corn yields or land values under normal conditions, it becomes more salient under climate extremes. In counties with greater upstream area, farmland values respond more favorably under persistent drought exposure, while corn yields increase more during wet years. These contrasting dynamics suggest that the economic importance of water access is highly context-dependent: flow volume may matter in average years, while timing and spatial priority become more consequential under climatic extremes.

Taken together, these results reveal that the benefits of upstream location are real but conditional. Under persistent dryness, upstream counties exhibit more stable farmland values, while in wet years, they capture greater gains in corn productivity. These advantages, however, are crop-specific and do not extend to extreme drought conditions or to soybean yields. The fact that upstream access matters most for corn—which is significantly more water-intensive and sensitive to moisture timing than soybean, underscores the importance of spatial water access for high-input crop systems. As climate variability intensifies, such spatial differences in stream access and yield responsiveness may contribute to widening disparities in agricultural outcomes. Recognizing these asymmetries is essential for designing effective adaptation strategies. Policies such as water-sharing agreements, compensation mechanisms, or institutional reforms may be needed to mitigate downstream disadvantage. In this context, upstream water access is not just a biophysical feature: It is a spatial asset with distributional consequences for climate resilience in the eastern United States.

Conclusion

This paper investigates how spatial access to surface and groundwater shapes agricultural outcomes under riparian water rights in the Eastern United States, both on average and in response to precipitation variability. Using county-level panel data and a flexible precipitation bin framework, we show that upstream counties—those with greater proximity to third-order streams—experience modest advantages in both land values under prolonged dryness and productivity gains during wet years for water-intensive crops. These benefits, however, are context-dependent: they do not extend to extreme drought conditions or to less water-intensive crops, and they are not mirrored by access to downstream streams.

Our benchmark analysis provides important context for these conditional effects. Groundwater access is consistently and positively associated with farmland value and crop yields—regardless of precipitation conditions or drought severity. In contrast, stream access reveals a more nuanced pattern: downstream proximity is associated with higher farmland values under average conditions, while upstream proximity is negatively associated with corn yields on average. This suggests that while stream position may confer climate-dependent benefits, groundwater remains the more robust driver of agricultural value and productivity across all conditions.

Our findings suggest that upstream location under riparian rights can offer de facto water security during certain climate regimes, but that this advantage is limited by both crop-specific water demands and the severity of climate stress. Groundwater access, by contrast, shows consistently positive associations with productivity in average years, but fails to offer clear buffering effects during drought. Taken together, these results underscore the importance of differentiating between water quantity and water priority when assessing agricultural resilience.

As climate variability intensifies, the spatial distribution of water access is likely to become an increasingly important determinant of economic outcomes across rural landscapes. Policymakers and water managers should recognize that riparian systems can produce asymmetric outcomes even in the absence of formal water rights enforcement. Proactive policies—including upstream–downstream coordination, compensation mechanisms, and infrastructure investments—may be necessary to ensure that water access remains both productive and equitable under future climate conditions.

That said, several limitations warrant attention. The current analysis assigns precipitation anomalies at the county level, treating each unit as an independent climate exposure. However, surface water systems are inherently interdependent, with downstream availability shaped by upstream precipitation. As such, county-level precipitation may imperfectly reflect true water stress in hydrologically connected regions. Future research should model these inter-county dependencies more explicitly, using National Hydrography Dataset (NHD) flowlines or Hydrologic Unit Code (HUC) watershed boundaries. This would enable more accurate upstream-weighted precipitation metrics and provide a hydrologically coherent lens on drought exposure.

Further extensions could examine how institutional variation in riparian enforcement, informal water-sharing norms, or legal doctrines affects the translation of spatial access into economic outcomes. Understanding the joint role of hydrology and governance will be critical for identifying both vulnerabilities and opportunities for adaptation in the face of increasing water stress.

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