



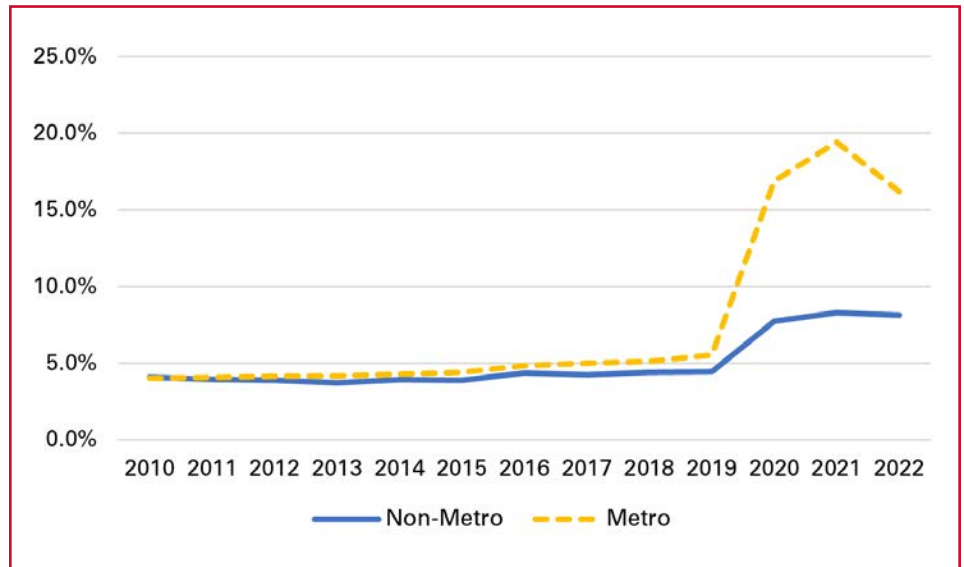
## Non-Metropolitan Areas Lag Behind in Work-from-Home Rates

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**R**ECENT YEARS have seen an explosion in the prevalence of individuals who work from home following social distancing efforts to reduce the spread of COVID-19 (Hegde and Van Parys 2024). Many workers were heavily exposed to new work patterns and communication methods, including more flexible work hours and virtual meetings via Zoom and other tools. During this experience, many firms and workers found working from home to be beneficial, and elevated work-from-home rates that began during the pandemic have largely stuck in the following years (Barrero, Bloom, and Davis 2023).<sup>1</sup>

However, the option to work from home is not available to all workers. Most jobs still involve many tasks that must be done in a traditional workplace.



**Figure 1. Work-from-home trends in metro and non-metro areas.**

Source: Based on author estimates using workers ages 18–64 in the American Community Survey.

Remote jobs tend to be information- and communication-intensive professional service occupations that were previously done in office settings. Workers in many fields such as manufacturing, retail, health care, and others do not have much ability to perform their jobs from home.

This short article documents and attempts to explain work-from-home differences between metropolitan and non-metropolitan area residents. Not too long ago, work-from-home rates were similar between metro and non-metro areas. However, increased work-from-home rates have been much

more pronounced in metro than non-metro areas. I consider differences by worker characteristics and the possible role that these play in metro-non-metro differences and find that worker demographics do not play a major role. However, education, occupation, and industry differences do play important roles in explaining the lower rates of work from home in non-metro areas. Broadband internet also appears to be an important factor. Thus, non-metro areas may still have untapped potential in increasing work-from-home rates to improve labor market outcomes for

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1. Notable benefits discussed include reduced time commuting and reduced need for office space (Aksoy et al. 2023; Behrens, Kichko, and Thisse 2024).

non-metro residents and strengthen local economies. Improved education and high-speed internet access are likely key policy goals to help achieve this.

### Work-from-home trends

Figure 1 presents work-from-home trends for workers ages 18–64 in the annual American Community Survey (ACS) from 2010 to 2022. In 2010, work-from-home rates were actually slightly higher for non-metro area residents (4.1%) than metro area residents (4.0%).<sup>2</sup> Work-from-home rates grew over time; and, by 2019, work-from-home rates had surpassed previous years in both metro and non-metro areas at 5.5% and 4.4%, respectively. Work-from-home rates skyrocketed during the pandemic and peaked in 2021 at 19.4% for metro areas but only 8.3% for non-metro areas. In 2022, the most recent ACS year available for this analysis, work-from-home rates had fallen somewhat to 16.2% for metro areas and to 8.1% for non-metro areas.<sup>3</sup>

Working from home is more practical in some occupations and industries than others. Additionally, work-from-home opportunities vary by education level. Figure 2 illustrates work-from-home trends for college graduates and non-college graduates in metro and non-metro areas. I define college graduates as persons with a bachelor's degree or higher. Multiple patterns emerge. The two groups of college graduates consistently have the highest work-from-home rates. However, there are major differences between college graduates in metro and non-metro areas. For 2022, 25.0% of metro college graduates worked from home, while only 13.6% of non-metro college

graduates worked from home. Among persons with less than a bachelor's degree (i.e., non-graduates), 10% of metro workers worked from home in 2022, while only 6.3% of non-metro workers worked from home.

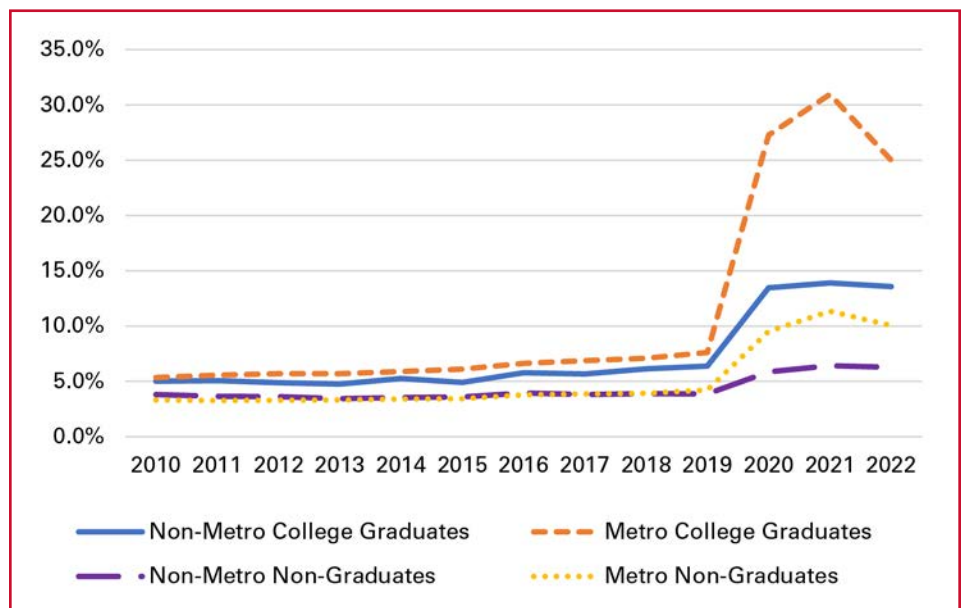
Work-from-home opportunities also depend on whether one is a paid employee or self-employed. Figure 3 documents differences between these groups over time and by metro and non-metro status. Self-employed workers have historically much higher work-from-home rates than paid employees. However, the increased prevalence of working from home that began during the pandemic is more pronounced for paid employees, especially employees residing in metro areas. In fact, the work-from-home rate for self-employed non-metropolitan residents did not meaningfully increase over time—the rate for this group was 19.8% in 2022, a slightly lower rate than in most years

before the pandemic.<sup>4</sup>

### Explanatory correlates

I next turn to considering the role of individual characteristics in explaining work-from-home rate differences between metro and non-metro areas in 2022 using multivariate regression analysis that controls for an increasing number of possible explanatory factors and seeing how the remaining work-from-home gap between metro and non-metro areas changes. More details are provided in the appendix with regression results in table A1.

In 2022, the work-from-home rate was 16.2% for metro workers and 8.1% for non-metro residents, resulting in a gap of 8.1 percentage points (i.e., the rate was twice as high in metro areas). Adding regression controls for age and sex produces a gap of 8.0 percentage points, which is virtually unchanged. Further adding controls for race and



**Figure 2. Work-from-home trends by college graduation and metro status.**

Source: Based on author estimates using workers ages 18–64 in the American Community Survey.

2. Some workers live and work in different areas. The current analysis measures metro and non-metro status based on where workers live. The ACS work-from-home question is based on where an individual “usually” works. Thus, an individual who works from home some but spends most of their work time at a worksite away from home would not be coded as working from home.

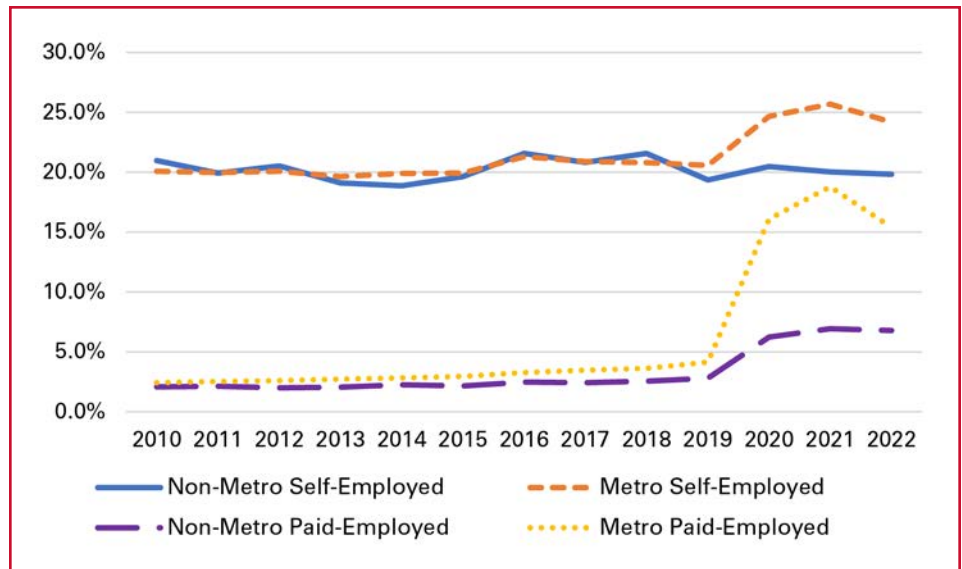
3. The ACS is conducted throughout a calendar year, but the publicly available data do not disclose the timing of individual surveys. Thus, the ACS is useful for annual averages but cannot be used to track changes within a given year.

4. Rates for this group exhibit some moderate year-to-year fluctuations but do not systematically trend up or down over the full period.

Hispanic ethnicity actually increases the metro-non-metro work-from-home gap to 8.9 percentage points. Also controlling for self-employment further pushes the gap between metro and non-metro areas to 9.0 percentage points. Thus, these factors discussed thus far do not explain the gap—race, ethnicity, and self-employment actually mask some of the gap that would occur if metro and non-metro areas did not differ along these dimensions.

I next add further controls for education, which reduces the gap to 6.5 percentage points. Adding detailed controls for industry and occupation of employment reduces the estimated work-from-home gap between metro and non-metro areas to 3.4 percentage points. Thus, education, occupation, and industry differences between metro and non-metro areas collectively explain the majority of the work-from-home difference between these areas in 2022. However, some portion remains unexplained even after accounting for these individual factors.

As a final piece of analysis, I next consider the potential role of broadband internet access by including local broadband rates as an additional explanatory variable. The results suggest that broadband has an important positive relationship with work-from-home rates. Broadband rates are also significantly lower in non-metro areas. Adding the broadband explanatory variable further reduces the work-from-home difference between metro and non-metro areas to only 0.2 percentage points and the difference is not statistically significant (i.e., the difference is not statistically distinguishable from zero). This analysis is illustrative and may not provide perfectly accurate estimates due to the exclusion of other potentially important variables. However, at face value, it appears that broadband access may be an important factor explaining work-from-home differences between metro and



**Figure 3. Work-from-home trends by self-employment and metro status.**

Source: Based on author estimates using workers ages 18–64 in the American Community Survey.

non-metro areas.

### Conclusion

Many non-metro residents have limited employment options in their area and have to settle for lower-paid work than they could get if they lived in a metro area (Winters 2020). Lack of employment opportunities is also a key factor for rural-urban migration as workers leave rural areas for better jobs and higher incomes in urban areas (Artz and Yu 2011). Working from home has potential to increase employment opportunities and incomes for rural residents by giving them access to employers and markets farther away—they can live in a rural area and work for an employer hundreds or even thousands of miles away. Increased incomes for remote workers in rural areas could also help fuel rural economic development due to employment multipliers. Rural remote workers who earn more money have more money to spend in their local community, which can create additional jobs and income for their neighbors. Remote work could one day be a central part of rural economies.

However, work-from-home rates in non-metro areas have been unspectacular

thus far. Work-from-home rates did increase in non-metro areas during the COVID-19 pandemic, but by 2022 only 8.1% of non-metro workers worked remotely. Furthermore, non-metro work-from-home rates lag behind the 16.2% rate for metro area workers. Education, occupation, and industry differences between metro and non-metro workers collectively explain the majority of their differing work-from-home rates, but observable worker characteristics do not explain some portion of it. Differences in local broadband rates appear to explain the remaining work-from-home rate difference between metro and non-metro workers.

This article suggests that non-metro areas have untapped potential to increase work-from-home rates and there is likely some role for public policy. First, rural education and training programs should increasingly prioritize access to and familiarity with remote work opportunities and practices. This can include familiarity with software for virtual meetings, file sharing, communication, etc. It also likely includes providing job seekers with information on where and how to find, apply for, and get hired for remote

jobs. Finally, high-speed internet access appears to be a significant obstacle to working from home for many rural residents. Improved internet speeds and reliability may have a plethora of benefits for rural residents, and remote work opportunities may be especially important among them. Increasing work-from-home rates may be critical for the economic health of non-metro areas in the coming years and decades.

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## Appendix

Table A1 uses multivariate regression analysis to examine the influence of individual characteristics and local broadband rates in explaining work-from-home differences between metro and non-metro workers ages 18-64 in the 2022 American Community Survey (ACS). The dependent variable is an indicator equal to 1 if a worker works

from home and 0 otherwise. The key explanatory variable is a Non-Metro indicator variable equal to 1 for workers residing in a non-metro area and 0 for metro residents. The key variable captures differences in work-from-home rates between metro and non-metro residents.

Table A1 includes seven columns with generally increasing sets of

controls for age, sex, race/ethnicity, self-employment status, education, industry, and occupation—Yes and No at the bottom of the table indicate inclusion for each column. Controls are detailed dummy variables. The change in the Non-Metro coefficient reflects the influence of additional regression controls. The final column also includes a variable for the local broadband rate

**Table A1. Work-from-Home Differences in 2022 for Non-Metro Relative to Metro Areas with Increasing Regression Controls**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Non-Metro	-0.081**	-0.080**	-0.080**	-0.089**	-0.090**	-0.065**	-0.034**	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
Local Broadband Rate								0.227**
								(0.010)
<b>Controls:</b>								
Age	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sex	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Race/Ethnicity	No	No	No	Yes	Yes	Yes	Yes	Yes
Self-Employment	No	No	No	No	Yes	Yes	Yes	Yes
Education	No	No	No	No	No	Yes	Yes	Yes
Industry	No	No	No	No	No	No	Yes	Yes
Occupation	No	No	No	No	No	No	Yes	Yes
R <sup>2</sup>	0.00	0.01	0.01	0.02	0.03	0.06	0.19	0.19

Notes: The sample includes workers ages 18–64 in the 2022 American Community Survey. Local broadband rate is computed for Census Public Use Microdata Areas (PUMAs). Standard errors are clustered by PUMA. \*\*Significant at the 1% level.

in the 2022 ACS computed as the percentage of adults (ages 18+) who have broadband internet in their home. The results in the final column indicate that the residual work-from-home rate difference between metro and non-metro areas (-0.002) is small and not statistically significant after including the full set of explanatory variables. Additionally, the coefficient of 0.227 for the local broadband rate suggests that a 10 percentage point increase in broadband would increase the work-from-home rate by 2.27 percentage points. For workers in the sample, the mean local broadband rate is 78.9% for metro residents and 64.3% for non-metro residents, a difference of 14.6 percentage points. Multiplying the broadband coefficient (0.227) by the broadband rate difference between metro and non-metro areas (0.146) indicates that broadband explains about 3.3 percentage points (0.033) of the work-from-home difference. ■

# Iowa Farmers' Attitudes and Behaviors Related to Weeds and Herbicide Resistance Management: Have They Changed over Time?

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**W**E CAN define herbicide resistance (HR) as the genetic adaptation of weeds to withstand herbicide applications (Owen et al. 2015). The threat of HR is fast becoming a significant threat to US agriculture, with many chemical treatments becoming less effective, threatening yields and profitability (Gould, Brown, and Kuzma 2018). It is likely that farmers will need to adjust their management practice to address the issue. However, little social science research has examined farmer perspectives regarding the threat of HR weeds and potential adaptive management practices. This report examines multiple years of data from the [Iowa Farm and Rural Life Poll \(IFRLP\)](#), an annual survey of Iowa farmers, to investigate how farmers' attitudes and behaviors related to HR have changed over time.<sup>1</sup>

## Current experiences, concerns, and management towards HR weeds

The 2022 IFRLP presented a series of statements on farmers' concerns, experiences, and management approaches to HR weeds. Eighty-seven percent of respondents indicated that they were concerned about HR weeds spreading to their farm operation from nearby farms (table 1). Furthermore, 85% reported making more than one herbicide application to a single crop in the previous five years. A similar percentage (84%) had made a change to

**Table 1. Farmer's Experiences, Concerns, and Management Approaches Related to HR Weeds**

	Yes	No	Don't Know
Are you concerned about herbicide-resistant weeds spreading to your farm operation from nearby farms?	87%	10%	3%
In the last five years have you made more than one herbicide application to a single crop in a single season?	85%	14%	1%
Over the last five years, have you changed your weed management program due to CONCERN about herbicide-resistant weeds on your farm?	84%	14%	2%
Have you found any weeds that you suspect are resistant to a single herbicide (i.e., single herbicide site of action) in fields that you farm?	67%	25%	8%
Over the last five years, have you changed your weed management program due to the actual PRESENCE of herbicide-resistant weeds on your farm?	66%	30%	4%
Have you found any weeds that you suspect are resistant to multiple herbicides (i.e., multiple herbicide sites of action) in any of the fields that you farm?	28%	50%	22%

their weed management program over the last five years due to concern about HR weeds on their farm, and around two-thirds (66%) reported changing management programs due to the *actual presence* of HR weeds on their farm. Approximately two-thirds (67%) also reported finding weeds suspected to be resistant to a single herbicide mode of action, and 8% reported finding weeds suspected of being resistant to multiple herbicide modes of action. A somewhat high proportion (22%) answered that they did not know if they had weeds that were resistant to multiple herbicide modes of action.

## Have farmers' attitudes towards

## technologies and management practices changed over time?

In 2014 and 2022 farmers were asked to rate their agreement on a five-point scale from "strongly disagree" to "strongly agree" on a series of statements linked to attitudes toward technologies and management practices. Table 2 summarizes the differences between those who agreed or strongly agreed to each statement in both years. Notably, agreement between the years remained stable. Only three items differed by more than 5%. Farmers were less likely in 2022 to agree that when new pest management technologies are introduced, it is only a matter of time before pests evolve resistance (73%).

1. This article summarizes results from the 2023 report, *Farmers' Attitudes and Behaviors Related to Weed and Herbicide Resistance Management*, available at <https://store.extension.iastate.edu/product/16896>.

In 2014, this number had been 82%. Similarly, concern towards the impact of pesticides on beneficial insects and microorganisms had reduced to 66% in 2022 compared to 74% in 2014. Finally, farmers' belief that premature evolution of resistant pests could be attributed to poor management by a few farmers declined from 69% in 2014, to 61% in 2022. Two statements about future pest management technologies allaying current concern stood out for their very low levels of agreement. Most farmers did not agree with items proposing that *Bt*-resistant insect pests and herbicide-resistant weeds were not a concern "because new technologies will be developed to manage them." In other words, they were not confident that new technologies will be sufficient to address the problem.

### Changes in behavior toward HR weed management over time

Table 3 shows a series of statements presented to farmers in the 2013, 2017, and 2022 IFRLP. There has been significant change in the percentage of farmers changing their weed management program due to concern about HR weeds. In 2013, just over half (52%) said that they had done this. By 2017, this was 77%; and, in 2022, 84% reported changing their program. The proportion of farmers making more than one herbicide application rose slightly from 81% in 2013 to 85% in 2022. Interestingly, the number of farmers developing their own herbicide programs declined over the previous decade. Only 36% of farmers said that they did this, compared to 45% in 2013. The proportion of farmers who hire custom applicators to spray herbicides remained stable, declining slightly from 65% in 2013 and 2017 to 63% in 2022.

### Changes to perceived effectiveness of HR management practices

There are many practices farmers can

**Table 2. Attitudes Toward Technologies and Management Strategies, Percent Agree or Strongly Agree, 2014 and 2022**

	2014	2022
<b>Attitudes toward technologies</b>		
I feel like pest (weed, disease, and insect) management is a never-ending technology treadmill.	91%	89%
When new pest management technologies are introduced, it is only a matter of time before pests evolve resistance	82%	73%
I am concerned about the impact of pesticides on beneficial insects, microorganisms, etc.	74%	66%
Seed and chemical companies should do a better job of keeping up with evolution of resistance in pests	66%	64%
<i>Bt</i> -resistant insect pests are not a major concern because new technologies will be developed to manage them	15%	13%
Herbicide-resistant weeds are not a major concern because new technologies will be developed to manage them	14%	9%
<b>Management practices</b>		
Poor management by a few farmers leads to premature evolution of resistant pests	69%	61%
Sometimes I think crop advisers recommend more pesticide use than is necessary	41%	41%
Pesticide resistance can be managed effectively by individual farmers	29%	27%
Farmers are less likely to use sound resistance management practices on rented land	15%	11%
The way farmers use pest management technologies does not really impact the rate at which resistance evolves	91%	89%

**Table 3. Selected Weed Management Behaviors, Percent Responding "Yes" in 2013, 2017, and 2022**

	2013	2017	2022
Over the last five years, have you changed your weed management program due to concern about herbicide-resistant weeds?*	52%	77%	84%
In the last five years, have you made more than one herbicide application to a single crop in a single season?	81%	83%	85%
Do you develop your own herbicide programs?	45%	36%	36%
Do you hire a custom applicator to spray herbicides?	65%	65%	63%

Note: The 2013 survey did not contain the word "concern." It read "due to herbicide resistant weeds."

enact to tackle the threat of HR weeds. In 2013 and 2022, farmers were asked to rate how effective they perceived each practice for this task on a four-point effectiveness scale from not effective at all (1) to very effective (4). Table 4 outlines how the proportion rating each practice effective or very effective changed during this time. Responses were reasonably stable across the decade.

However, the perceived effectiveness of cover crop use increased 10 percentage points. Other substantial changes included multiple modes of action in each application and use of crops resistant to non-glyphosate herbicides, which both increased by 8 percentage points. Practices with declines in perceived effectiveness included high planting rates, which dropped 10

percentage points, and tillage, which dropped by 5 percentage points.

### Attitudes toward alternative management approaches

In 2022, farmers were also surveyed on their attitudes towards collaborative initiatives aimed at tackling HR. As shown in table 5, almost half (47%) indicated that a local organization led by farmers would be an acceptable approach to tackling HR weeds. Willingness to participate in a community-wide cooperative group was much lower, with 18% being for this method, and 41% against. However, 41% also suggested that they did not know, indicating a level of apathy or uncertainty regarding community management approaches. Finally, the idea of a government-related mandate was the least favored potential plan to manage HR weeds. Only 6% said that the government should be involved in this way. These results are useful to consider in the future development of policies and initiatives to tackle HR weeds.

### Conclusion

Overall, survey results suggest that concern for HR weeds among Iowa farmers has grown over the previous decade. This is best demonstrated by the percentage of those changing their weed management programs in the previous five years due to concern for HR weeds growing from 54% in 2013 to 84% in 2022. Iowa farmers are also increasingly apathetic towards the idea that new technologies will be able to manage HR weeds with only 9% agreeing or strongly agreeing with this in 2022 compared to 14% in 2014. To combat the issue of HR, farmers increasingly view practices such as crop rotation and cover crops as being more effective. Going forward, farmers also appear to favor collaboration with local farmer-led organizations compared to working with community cooperatives and the government to tackle HR weeds.

**Table 4. Percent of Farmers Rating HR Management Practices as Effective or Very Effective, 2013 and 2022**

	2013	2022
Rotation of crops	82%	86%
Multiple modes of herbicide action used each season	77%	82%
Multiple herbicide application timings	83%	80%
Multiple modes of herbicide action used in each herbicide application	71%	78%
Tillage	72%	67%
Inclusion of a forage in the rotation	57%	60%
Mechanical control (e.g., cultivation)	55%	58%
Use of crop cultivars that are resistant to herbicides other than glyphosate	45%	53%
Use of a cover crop	39%	49%
Higher planting rates	40%	30%

**Table 5. Attitudes Toward Alternative Management Approaches**

	Yes	No	Don't Know
Would it be acceptable for a farmer-led local organization to help local farmers to develop plans to manage herbicide-resistant weeds?	47%	22%	31%
Would you be willing to participate in a community-wide cooperative weed management group?	18%	41%	41%
Should the government require farmers to develop an approved plan to manage herbicide-resistant weeds?	6%	78%	16%

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[management.](#) ■

### Suggested citation

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# Land Values, Interest Rates, and the Federal Reserve's Expectations

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This is the second in a series of three articles evaluating the relationship between farm income, interest rates, and other factors and land values. The first article is available [here](#).

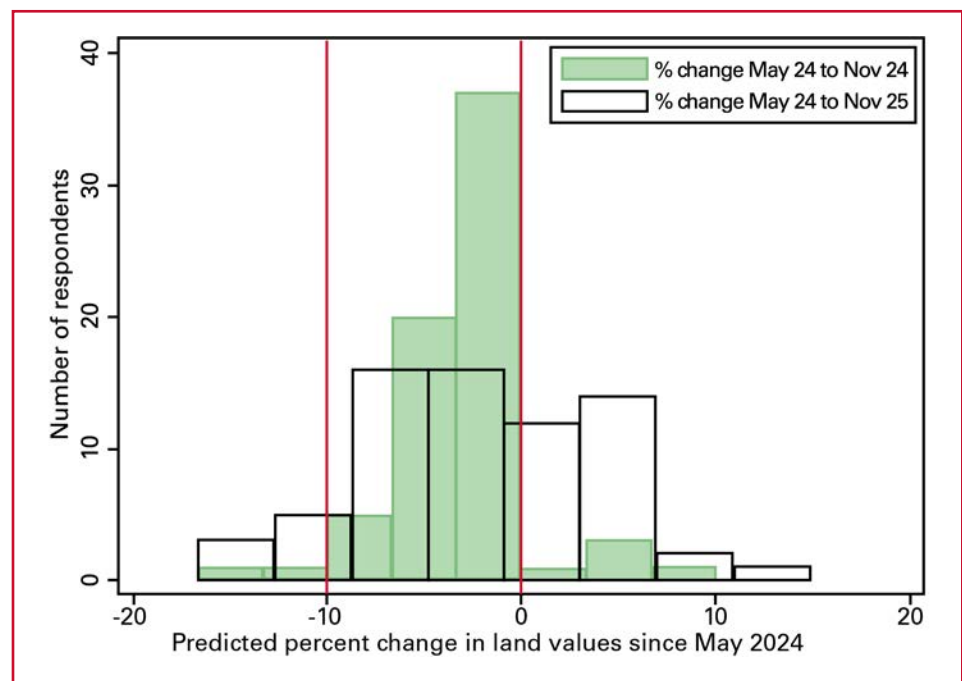
**D**URING THE COVID-19 pandemic, the Federal Reserve implemented its fourth round of quantitative easing, a monetary policy where the central bank purchases securities to increase the money supply and encourage lending and investment in the United States to stimulate economic activity. This resulted in historically low interest rates through 2020 and 2021. In mid-2022, the Federal Reserve shifted to quantitative tightening, the opposite of easing, introducing aggressive interest rate hikes to curb high inflation. Despite these hikes, land values continued to rise through 2022 and showed a modest increase in 2023.

Land values are fundamentally the present value of all expected future income streams derived from the land discounted by prevailing interest rates. When interest rates increase, the discount rate rises, leading to a decrease in the present value of future income streams and, consequently, a decline in land values. Conversely, lower interest rates reduce the discount rate, increasing the present value of future incomes and pushing up land values. Therefore, the low rates during the pandemic contributed to rising land values as the cost of borrowing was minimal and the discount rate applied to future incomes was low. However, it takes a few years for land values to

**Table 1. Short-Term and Long-Term Expected Percentage Change in Iowa Land Values Compared to May 2024**

	Iowa Overall	Northwest Iowa	Northeast Iowa	Southwest Iowa	Southeast Iowa
Nov. 2024	-2.14%	-1.92%	-2.23%	-2.84%	-1.72%
Nov. 2025	-2.34%	-2.24%	-3.84%	-0.72%	-2.37%
Nov. 2026	-0.19%	-0.14%	-2.39%	2.45%	-0.26%
Nov. 2030	14.64%	13.08%	12.18%	24.71%	11.15%
Nov. 2040	34.86%	35.50%	27.62%	42.84%	34.91%

Source: Author's calculations based on the 2024 96th Annual Iowa State University Soil Management Land Valuation Conference participants' land value forecasts (Chandio 2024).



**Figure 1. Six- and 18-month change expected in Iowa land values.**

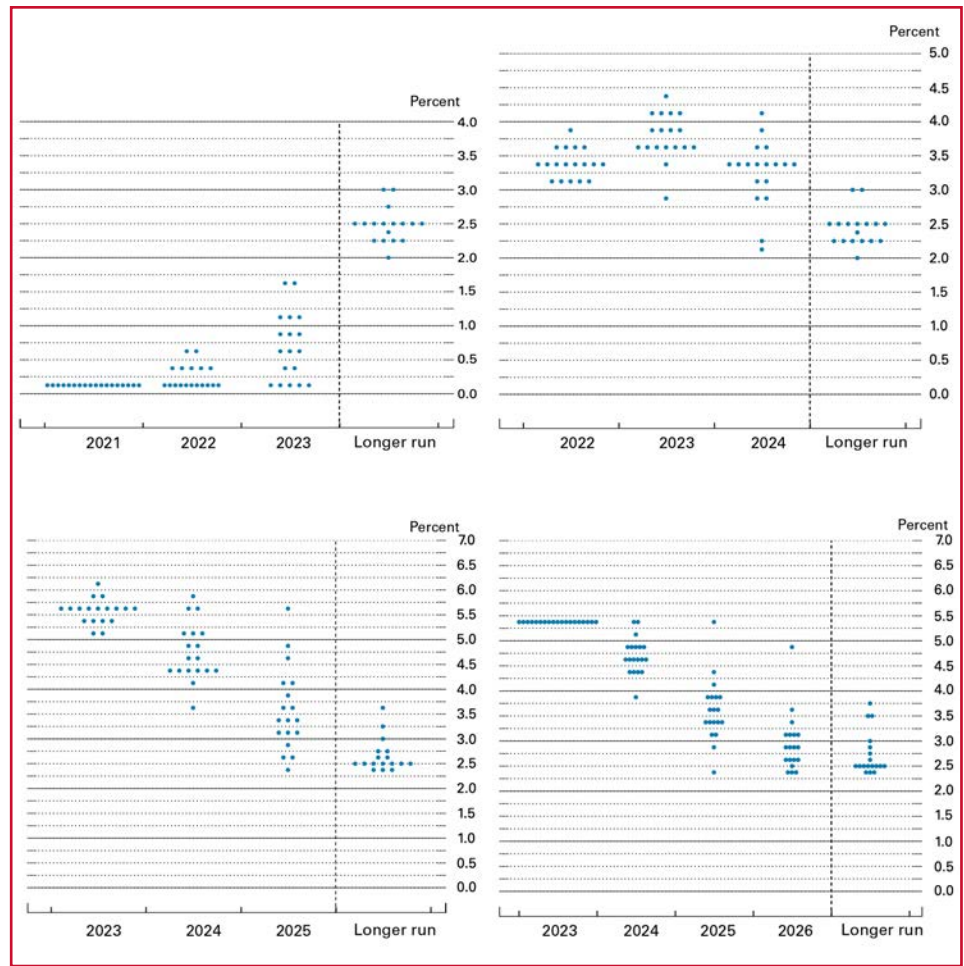
Note: The figure shows a bar chart of participants' expected change in land value in six months (green) and in 18 months (white), depicting an expectation of land values declining by less than 10% by most participants within this year and land values either declining or rising each by less than 10% by November 2025.

Source: Author's calculations based on the 2024 96th Annual Iowa State University Soil Management Land Valuation Conference participants' land value forecasts (Chandio 2024).

fully reflect an interest rate change (Basha et al. 2021), making the expectations of interest rates all the more important. Inertia in the real estate market, where buyers and sellers often base their decisions on long-term expectations and past trends rather than immediate changes, can partly explain this phenomenon.

Land markets in Iowa have begun to experience a steady decline in values, with the [Realtor Land Institute's most recent report](#) suggesting an approximately 3% decline in land values between September 2023 and March 2024 (Siefert and Vegter 2024). In contrast, the [Iowa State University Land Value Survey](#) showed an approximate 3% rise in statewide land values between November 2022 and November 2023 (Chandio 2023), indicating that declines in values have occurred more recently. Moreover, we expect similar decreases in the next few years, with a recovery in the land markets predicted for 2026 and beyond (see table 1 and figure 1). The observed and anticipated declines are closely related to changes in interest rates, which, after farm income, are the most important factor determining farmland values. Interest rates have been monitored and adjusted over the last few years under the Federal Reserve's quantitative easing policy.

The Federal Reserve's dot plot, a chart that summarizes the projections of the Federal Open Market Committee (FOMC) members regarding future interest rates, offers insights into their expectations, which are critical in forecasting the direction of land markets. It is important to note that these projections are expectations and are subject to change, as we will observe when comparing different dot plots. Examining the dot plots from June 2021, June 2022, June 2023, December 2023, and March



**Figure 2. Federal Reserve's dot plots for previous years.**

*Note:* Each shaded circle indicates the value (rounded to the nearest 1/8 percentage point) of an individual participant's judgment of the midpoint of the appropriate target range for the federal funds rate or the appropriate target level for the federal funds rate at the end of the specified calendar year or over the longer run.

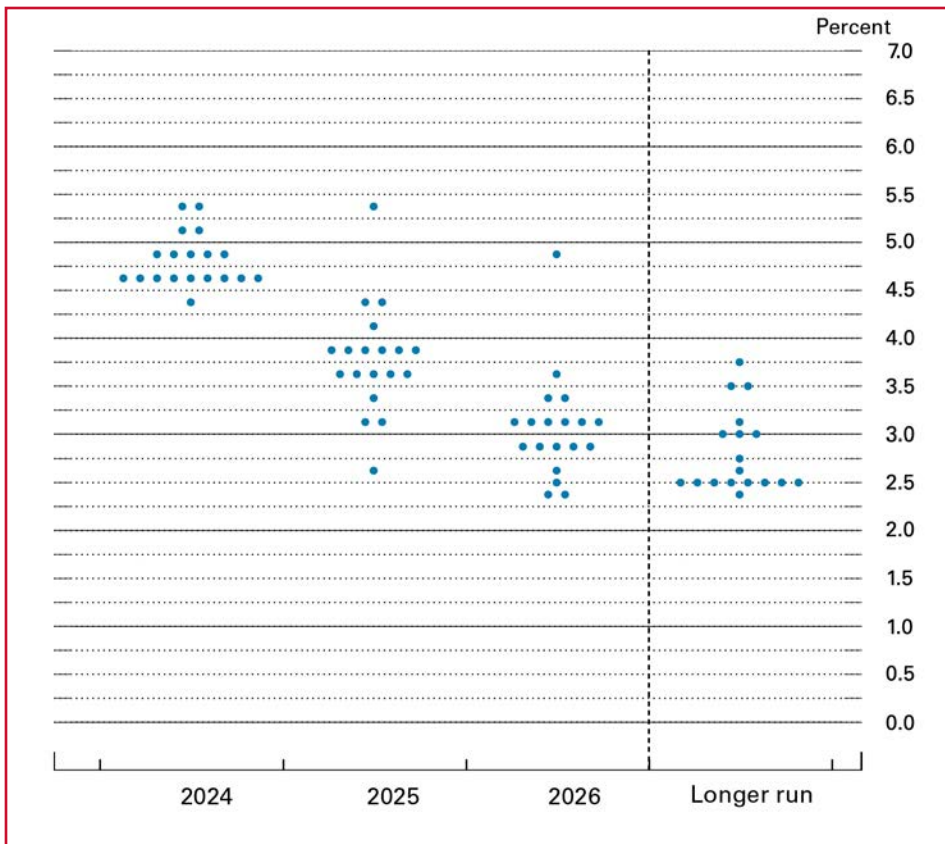
*Source:* The Federal Open Market Committee participants' assessments of appropriate monetary policy (FOMC 2024).

2024 reveals significant shifts in these expectations (figure 2). The anticipated interest rates can help us determine the rough direction and magnitude of land values over the next few years.

In June 2021, during the pandemic, the dot plot showed that rates were projected to remain low through 2021 and 2022, with only gradual increases anticipated in 2023 and longer-run rates stabilizing around 2.5% in 2024 and beyond. The low rates and continued expectations for low rates in the coming years supported the record-high land values.

A year later, at the peak of inflation, the June 2022 projections indicated significant increases in projected rates for 2022 and 2023 compared to the previous year's projections, with a peak of around 3.5% expected in 2023 and slight decreases in the longer run to stabilize around the same rate of about 2.5%. This suggested upcoming rate hikes, initiating concerns about future land value declines.

The shift from very low to higher projected interest rates indicates significant monetary tightening. However, despite facing downward pressure, farmland values have not



**Figure 3. Federal Reserve's dot plots for March 2024.**

Note: Each shaded circle indicates the value (rounded to the nearest 1/8 percentage point) of an individual participant's judgment of the midpoint of the appropriate target range for the federal funds rate or the appropriate target level for the federal funds rate at the end of the specified calendar year or over the longer run.

Source: The Federal Open Market Committee participants' assessments of appropriate monetary policy (FOMC 2024).

yet fallen significantly. This is because the lagged effect of persistently low rates in the past couple of years still outweighed the initial effect of the recent rate increases. Moreover, future projections and realizations of interest rates will determine whether the negative effect of interest rate increases will result in a land value decline. If the interest rate increases are modest, subsequent rate cuts or other positive market factors may counter their lagged effects, stabilizing land values.

The Federal Reserve Bank's December 2023 dot plot shows that most officials expected rate cuts in 2024, likely in the latter half of the year. As the lagged impact of previous hikes is realized, it can be offset

with rate cuts, stabilizing the land markets. However, the March 2024 FOMC meeting's dot plot indicates that experts expect interest rates to range from 4.5% to 5.5%, canceling expectations of significant rate cuts in 2024 (figure 3). With rates projected to remain high in the short term before declining, pressure on farmland values will likely persist. However, if the projected decline in interest rates materializes, it could stabilize or potentially increase farmland values as borrowing becomes more affordable and the discount rate on income decreases. Thus, while interest rate increases and other economic factors have built enough pressure for land values to start declining, the decline

will likely continue, given an extended period of high interest rates continuing into 2025.

Additionally, we cannot overlook the role of inflation expectations. Interest rate predictions or expectations in the dot plot correspond to inflation expectations in the next few years. The Federal Reserve's monetary policy aims to balance inflation control with economic growth, and their interest rate decisions are pivotal in this balancing act.

### Conclusion

The relationship between land values and interest rates is complex, influenced by immediate and long-term expectations shaped by Federal Reserve policies. The dot plot remains a vital tool in predicting these trends, providing insight into how future rate expectations will shape land markets. As the effects of the 2022 hikes are fully realized, a clearer picture of land market dynamics will emerge. Monitoring Fed announcements and economic indicators will be crucial in anticipating market adjustments. Current trends suggest a period of adjustment, with potential stabilization and recovery as markets adapt to the new interest rate environment.

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# The Ag Outlook for 2024/2025

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**W**ITH PLANTING mostly completed and grilling season underway, USDA has provided an update on the crop and livestock outlook for the coming 12–18 months. Compared to the most recent past summers, the June World Ag Supply and Demand Estimates (WASDE) report was less of a new news story and more of confirmation of prior trends. This outlook will shift over the coming months, but these estimates outline the most likely scenario given today's conditions.

For livestock, the 2024 marketing year is shaping up to be a strong production year despite some production challenges (table 1). While the beef and turkey sectors are experiencing production cuts due to a variety of impacts from the multi-year issues of drought and avian influenza, the pork and broiler sectors continue to press overall meat production higher. On the price side, cattle, hogs, and broilers are, on average, capturing slightly higher prices. However, the strong turkey prices from 2023 have not sustained themselves into 2024. US meat exports have stepped back in 2024, with less beef and broiler meat exiting the country. Pork exports have risen, but not enough to offset the trend from the other meats.

For 2025, the meat outlook is for overall production to be relatively steady. However, the trends over the past couple of years continue. Beef production will continue to decline with the smaller cattle herd, but gains from the other meats roughly offset the retreat in beef production. With the most recent update, USDA added 250 million pounds to beef supplies, based on relatively high

dressed weights and larger expected feedlot placements in the fourth quarter of 2024. Pork production keeps growing as productivity gains via higher numbers of pigs saved per litter overwhelm lighter numbers of farrowings. USDA projects broiler and turkey production will expand as well, despite the lingering challenges from avian influenza. In general, livestock prices are projected to move in the opposite direction, with cattle prices rising and hog and broiler prices falling. Turkey is the exception, with higher prices projected for the coming year. The price changes are relatively minor, compared to the price shifts over the past 2–3 years. Compared to the 2024 price estimates, cattle prices are projected to be 2.4% higher, hog prices are 2% lower, broiler prices are down 1.2%, and turkey is up 8.5%. Compared to 2022 price levels, cattle prices are projected to be 30.5% higher, hog prices are 15.7% lower, broiler prices are down 10.3%, and turkey is down 32%. Meat exports are expected to be

slightly higher. Beef exports are forecast to fall to 2.5 billion pounds, declining by roughly 320 million pounds. Pork exports are expected to increase by 250 million pounds, with broiler exports rising by 141 million pounds.

On the crop side, the May WASDE report is usually based on the acreage estimates from the March Prospective Plantings report and the trend yield released at the Ag Outlook Forum in February. With the June WASDE, USDA holds firmly to those earlier estimates, as there were no changes for either the 2023 or 2024 corn crops. With that said, there are still sizable shifts between the years. The March Prospective Plantings report shows only 90 million acres planted to corn. Thus, even with a projected record trend corn yield of 181 bushels per acre, USDA expects 2024 corn production to be nearly 500 million bushels less than the 2023 total (table 2). However, with expected corn stocks at the end of the 2023 marketing year, which concludes on August 31, 2024,

**Table 1. USDA's Livestock Projections**

	2024		2025		
	Forecast	Change from May	Forecast	Change from May	Change from 2024 to 2025
(Billion Pounds)					
Production					
Beef	26.59	0.00	25.37	0.25	-1.22
Pork	28.10	0.04	28.40	0.00	0.30
Broilers	46.87	0.06	47.55	0.00	0.69
Turkey	5.23	0.02	5.32	0.00	0.09
Total Meat	107.54	0.11	107.39	0.25	-0.15
(\$ per Cwt.)					
Prices					
Steers	184.01	0.50	188.50	0.25	4.49
Hogs	61.24	-1.25	60.00	0.00	-1.24
(Cents per Pound)					
Broilers	127.50	0.50	126.00	0.00	-1.50
Turkey	96.80	1.50	105.00	0.00	8.20

Source: USDA-WAOB.

rising to over 2 billion bushels, total corn supplies this fall are projected to be 180 million bushels higher than last year.

Corn usage is projected to increase, but not quite at the pace of corn supplies.

Feed and residual use of corn is expected to rise by 50 million bushels, paralleling a 50 million bushel increase in exports.

Corn usage for ethanol remains strong but stable at 5.45 billion bushels.

USDA projects 2024/25 corn ending stocks (so the corn still available in the market at August 31, 2025) at 2.1 billion bushels.

Higher stocks tend to go along with lower prices. For the 2023 crop, the current season-average price estimate is \$4.65 per bushel. For 2024, the price estimate is \$4.40 per bushel.

Currently, corn futures prices indicate a 2024 price estimate in the \$4.65 range.

Thus, the futures market is a bit more optimistic for corn prices over the next 12–18 months, likely based on weather concerns both for the United States and globally.

The soybean estimates also did not change much with the June WASDE report (table 3). The only change was a 10 million bushel decline in soybean crush for the 2023 crop, as USDA pointed to lower domestic soybean meal use this year. However, there are again significant changes between the years. Much of the area that left corn production entered soybean production. With nearly 3 million more acres planted to soybeans, expected production is set to reach 4.45 billion bushels, an increase of 285 million bushels from last year; and as with corn, stocks going into the harvest season are set to be higher, with 350 million bushels in storage at the end of August. Thus, total soybean supplies are projected to exceed 4.8 billion bushels. The parallels with corn continue, as the growth in usage is not quite enough to reduce stocks at the end of the 2024 marketing year. Soybean crush is projected to increase by 135 million bushels, based on continuing

**Table 2. Corn Supply and Use**

	2023		2024	
	Estimate	Change from May	Forecast	Change from 2023 to 2024
Area Planted (mil. acres)	94.6	0.0	90.0	-4.6
Yield (bu./acre)	177.3	0.0	181.0	3.7
Production (mil. bu.)	15,342	0	14,860	-482
Beg. Stocks (mil. bu.)	1,360	0	2,022	662
Imports (mil. bu.)	25	0	25	0
Total Supply (mil. bu.)	16,727	0	16,907	180
Feed & Residual (mil. bu.)	5,700	0	5,750	50
Ethanol (mil. bu.)	5,450	0	5,450	0
Food, Seed, & Other (mil. bu.)	1,405	0	1,405	0
Exports (mil. bu.)	2,150	0	2,200	50
Total Use (mil. bu.)	14,705	0	14,805	100
Ending Stocks (mil. bu.)	2,022	0	2,102	80
Season-Average Price (\$/bu.)	4.65	0.00	4.40	-0.25

Source: USDA-WAOB.

**Table 3. Soybean Supply and Use**

	2023		2024	
	Estimate	Change from May	Forecast	Change from 2023 to 2024
Area Planted (mil. acres)	83.6	0.0	86.5	2.9
Yield (bu./acre)	50.6	0.0	52.0	1.4
Production (mil. bu.)	4,165	0	4,450	285
Beg. Stocks (mil. bu.)	264	0	350	86
Imports (mil. bu.)	25	0	15	-10
Total Supply (mil. bu.)	4,454	0	4,815	361
Crush (mil. bu.)	2,290	-10	2,425	135
Seed & Residual (mil. bu.)	114	0	110	-4
Exports (mil. bu.)	1,700	0	1,825	125
Total Use (mil. bu.)	4,104	0	4,360	256
Ending Stocks (mil. bu.)	350	10	455	105
Season-Average Price (\$/bu.)	12.55	0.00	11.20	-1.35

Source: USDA-WAOB.

renewable diesel development. Soybean exports are expected to rebound by 125 million bushels in the coming

marketing year. But 2024 ending stocks are currently set at 455 million bushels, nearly 200 million bushels higher than

we saw last fall. While the 2023/24 season-average price estimate has not moved from \$12.55 per bushel, the price is \$1.65 lower than the previous year. That pattern continues going forward—the 2024/25 season-average price estimate is \$11.20 per bushel, down another \$1.35 per bushel, as those projected stocks continue to build, despite the renewable diesel boost. Current soybean futures are in line with the USDA price estimate.

The agricultural economy took a big step back in 2023. Net farm income fell from the record levels, as crop prices and revenues retreated and livestock returns were mixed. The current outlook for 2024/2025 shows the drop in net farm income will likely continue, but some commodities may have already seen their low spot. While the lower crop prices have lowered prospects for crop producers, the lower feed costs have alleviated pressures for livestock producers. The futures markets for both corn and soybeans are indicating relatively stable prices looking into the 2025 marketing years, signaling the potential for more stable net farm incomes over the next year.

### **Suggested citation**

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# Corporate and Foreign Land Ownership in Iowa

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IOWA GOVERNOR Kim Reynolds signed the latest foreign agricultural land ownership law on April 9, 2024. This new legislation enhances reporting requirements, increases fines for noncompliance, and strengthens enforcement of Iowa's laws restricting foreign ownership of agricultural land. Among the strictest in the nation, Iowa's restrictions on foreign ownership predate its 1975 restrictions on corporate farming. This article provides a brief overview of both corporate and foreign ownership regulations in Iowa.

## Corporate farmland ownership

Institutional and corporate ownership of land in Iowa has increased from 17% of Iowa farmland acres in 2002 to about 40% of farmland acres in 2022 (see table 1), with both local and institutional investors explaining about one-quarter of Iowa's recent land purchases (Chandio 2023). The investor and institutional ownership of farmland in Iowa, nevertheless, operates with a lot of restrictions.

Iowa enacted its first regulation of corporate farming in 1975, following a number of other Midwestern states, specifically Minnesota, that banned corporate ownership of farmland or use of farmland for agricultural purposes by corporate entities (Knoeber 1997). The objective of these laws was to prevent monopolistic practices that could harm family farmers in Iowa. These laws prohibited vertical integration, where a company controls both production and processing. In 2003, Smithfield Foods challenged this law, leading to a consent decree under which the Iowa Attorney General agreed not to enforce the law

against processors for 10 years. The decree expired in 2015, but Iowa has taken no further action (Tidgren 2015).

Today, Iowa maintains some of the strictest corporate ownership restrictions in the country, detailed in Iowa Code 9H.4–9H.5. These laws outline the restrictions and requirements for corporate entities, such as corporations, LLCs, trusts, and certain partnerships, which the laws generally restrict from owning agricultural land, with several exceptions. Family-owned corporations, LLCs, and trusts can own farmland if over 60% of their gross income over the past three years is farm-related, explaining most of the institutionally owned Iowa farmland. Another exemption is given to authorized corporations, LLCs, and trusts with less than 25 beneficiaries who can operate agricultural land for profit, although with other regulations. These laws generally prevent corporations, LLCs, or trusts from acquiring or leasing land “suitable for use in farming in Iowa.” Exceptions to this law allow corporations or other

entities to take a security interest in agricultural land, conduct various research and experimental activities on agricultural land, or acquire agricultural land for non-farming purposes. "Family" entities are not subject to these restrictions, and certain "authorized" entities may own or lease up to 1,500 acres of agricultural land (Tidgren 2015).

## Foreign farmland ownership

Iowa Code 9I restricts foreign governments and investors from owning land in Iowa, with exceptions for those who owned land before 1980, those inheriting the land, those using the land for research purposes, and those purchasing up to 320 acres of agricultural land for non-farming purposes. These purchasers must convert that land to a non-farming purpose within five years. These examples do not present all the exceptions, only a major few. The first federal law regarding foreign-owned land, enacted in 1978, was the Agricultural Foreign Investment Disclosure Act (AFIDA). This law

**Table 1. Percentage of Iowa Farmland Owned by Ownership Type**

	2002	2007	2012	2017	2022
Sole owner	28%	29%	25%	22%	23%
Joint tenancy	37%	35%	32%	28%	29%
Tenancy in common	12%	10%	8%	8%	5%
Partnership	2%	3%	3%	3%	2%
Estates	4%	3%	3%	4%	2%
Trusts	8%	10%	17%	20%	23%
Corporations	7%	9%	7%	10%	6%
LLC	1%	1%	5%	5%	9%
Government/institution	1%	1%	<1%	-	<1%

Note: The trusts category here includes revocable living trusts, which are not considered "trusts" under the corporate farming laws and, hence, are not subject to restriction.

Source: 2022 Iowa Farmland Ownership and Tenure Survey report (Tong and Zhang 2023).



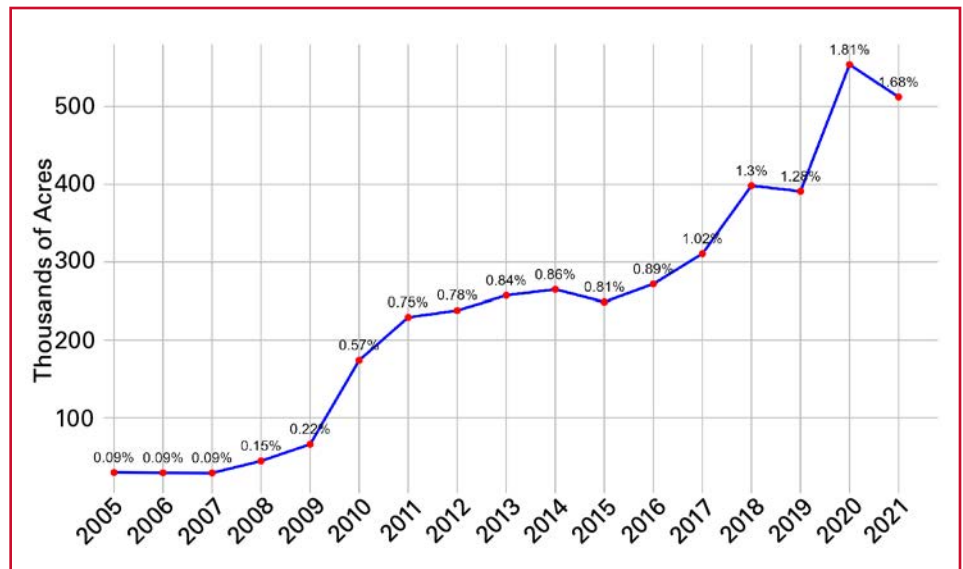
requires foreign entities to report their land ownership and practices to the federal government annually, allowing the public to access this information by county.

In February 2024, Iowa Governor Kim Reynolds signed into law a bill updating the reporting requirements for foreign land ownership. The new law requires foreign purchasers of agricultural land to register with the secretary of state's office, in addition to continuing to file biennial reports. The registration must include the identity of the owners, the purpose for which the land will be used, the authority under which they are purchasing the property, and all other interests they hold in agricultural land totaling 250 acres or more. Those currently owning agricultural land have 180 days to register. Registration reports and biennial reports are confidential and not available to the public. The attorney general, the governor, and the general assembly may, however, access them for public policy purposes.

The law requires the secretary of state to create an annual summary of registrations and biennial reports. It also gives Iowa's attorney general the right to subpoena records and require compliance with law. Finally, the law enhances penalties associated with violations. The civil penalty for failing to file a timely registration increased to an amount not more than 25% of the county's assessed value of the subject agricultural land for the previous year for "each offense." Additionally, the civil penalty for failing to file a timely biennial report or filing false information in such a report increased to an amount of not more than \$10,000.

### Trends in foreign farmland ownership

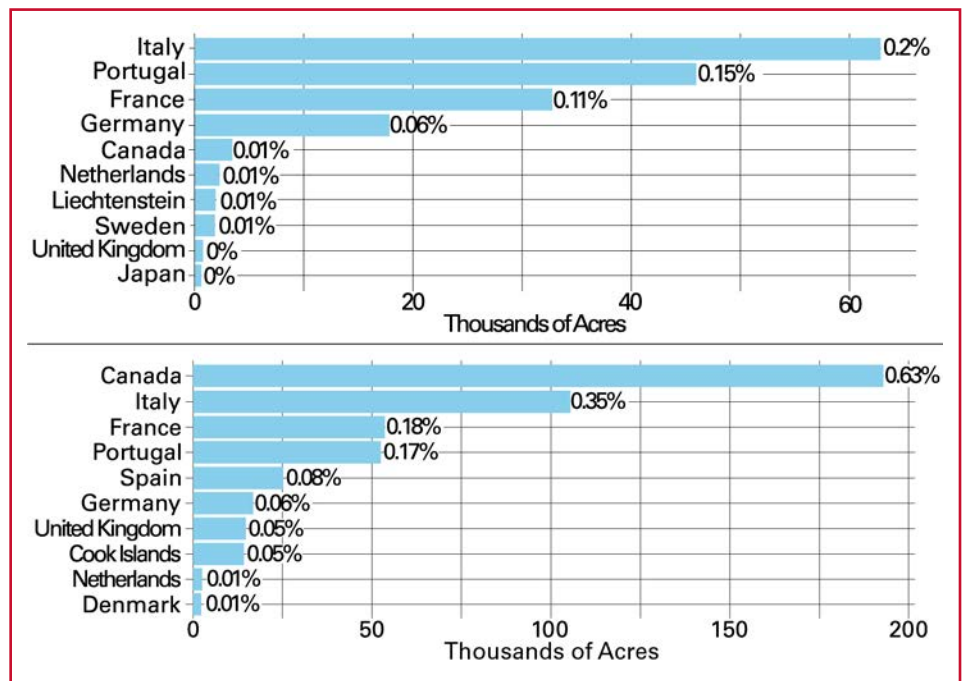
Foreign land ownership in Iowa increased significantly starting in the late 2000s, with foreign-owned agricultural



**Figure 1. Total and percent of Iowa farmland with foreign interest (ownership and lease).**

Note: The total acres represented here include crop, pasture, forest, and other agricultural, as well as non-agricultural use.

Source: Authors' compilation based on USDA FSA AFIDA annual reports (USDA FSA 2024). State-level total agricultural acres are based on 2002, 2007, 2012, and 2017 US Censuses of Agriculture (USDA NASS 2024).



**Figure 2. Top 10 countries with foreign interest in Iowa land in 2010 (top) and 2021 (bottom).**

Note: The top panel ranges to about 65,000 acres of land, while the bottom panel goes to 200,000 acres

Source: Authors' compilation based on USDA FSA AFIDA annual reports (USDA FSA 2024). State-level total agricultural acres are based on 2002, 2007, 2012, and 2017 US Censuses of Agriculture (USDA NASS 2024).

land rising from 29,609 acres in 2005 to 170,852 acres in 2010. This corresponds

to increased interest in farmland as a portfolio investment, especially after

the financial crisis (Choi 2023; Baker, Boehlje, and Langemeier 2014; Fairbairn 2014; Kuethe, Walsh, and Ifft 2013).

To put this in perspective, these acres represent 0.09% and 0.57%, respectively, of total Iowa farmland acres according to the census of agriculture (see figure 1).

Another surge in foreign interest in Iowa farmland occurred after 2015, corresponding to declining Iowa farmland values and low interest rates, which presented promising investment opportunities that attracted both foreign and local buyers. Between 2015 and 2021, foreign acres owned or leased in Iowa almost doubled again (figure 1) from 248,647 acres in 2015 to 512,384. Most of the over 500,000 acres with foreign interest in 2021 represent long-term leaseholds especially by energy companies.

Figure 2 shows the top 10 countries that owned or leased Iowa farmland in 2010 and over a decade later in 2021. Currently, Canada is the largest foreign holder of Iowa farmland, owning 0.63% or 192,968 acres. Canada is also the largest landholder of all US agricultural land, claiming 32% of the total land base with foreign interest in the United States (Taylor, Zhang, and Attah 2023). While the top 10 foreign holders of Iowa farmland remained quite similar from 2010 to 2021, Cook Islands and Denmark have been the two new additions to the top 10 within this period.

## Conclusion

The topic of land ownership, especially by corporations and foreign entities, has garnered a lot of attention recently, with specific concerns about land ownership by US adversaries. It is important to note that, first, the total amount of Iowa land owned and leased by foreign entities is quite small, making up less than 2% of Iowa farmland. Second, most of that interest comes from wind and solar energy companies, similar to the

nationwide trend (Taylor, Zhang, and Attah 2023).

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# Antibiotics Policy Prescription through Prescription Policy in US Agriculture

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**W**ORLD WAR II saw cheap mass-produced antibiotics due in part to developments by Charles Pfizer & Company, helping to manage the many bacterial diseases that proliferate in war-time conditions.<sup>1</sup> A decade after the war the same company developed markets for antibiotics in animal protein production as therapy and as growth promoters (Finlay 2004). These markets expanded rapidly through the last decades of the twentieth century as a low-cost means of managing hygiene in farm conditions. Bacteria are short-lived and remarkably adaptable creatures that freely swap DNA content asexually both within and between species so that resistance is inevitable. In 1969 an official United Kingdom government report recommended controls on agricultural antibiotic usage so as to protect efficacy in human medicine (Swann 1969). The half-century since the early 1970s has seen expanded regulation on antibiotics use in agriculture, first in high-income countries and more recently in lower income countries. Underlying this expansion has been the growing prevalence of bacterial resistance to antibiotics, a dearth of innovation in antibiotics, and the underlying constrained revenue problem whereby new antibiotics should be used sparingly in order to protect against resistance development (Laxminarayan et al. 2024).

The purposes of this article are to describe recent United States

regulatory endeavors to delimit the use of antibiotics in agriculture as well as to discuss how that has affected demand for services, in particular information services. The Food and Drug Administration (FDA), the relevant administrative authority, implemented the regulations, which involved assigning practicing veterinarians as stewards on behalf of the public. In this new role, veterinarians have become gatekeepers when weighing the benefits of antibiotics use as an input into producing plentiful food protein against the uncertain and possibly very large costs of increasing selection pressure toward resistance among bacteria. In this role, veterinarian gatekeeping offers an alternative to a corrective tax as a means of deterring against input choice levels that maximize user benefits but involve excessive use for the public good. Perhaps more fundamentally, veterinarians have also become guardians against use borne out of unawareness and uncertainty. Farmers may apply the input because establishing certainty about need is costlier than summarily administering an input whose benefit-to-cost ratio is very high when needed.

## Prescription policy in the United States

Since the 1950s antibiotics have been incorporated into animal feed and water to prevent disease and promote growth by facilitating feed conversion to animal produce. Commencing with

the Veterinary Feed Directive (VFD) in 2017, the FDA severely curtailed such administrations by disallowing growth promotion as a rationale for including antibiotics in feed or water and by allowing a veterinarian to establish whether disease prevention was a warranted justification under the circumstances. The veterinarian issuing the feed prescription should have standing in the form of an ongoing veterinarian-client-patient relationship (VCPR) so that the veterinarian is well-acquainted with client circumstances. A veterinarian who does not take seriously the antibiotics stewardship assignment may face penalties from either their state licensing board or the federal FDA.

A separate initiative, referred to as prescription regulation (PR), was put in place commencing 2023. As of 2024 a veterinarian must prescribe under VCPR conditions all remaining animal health antibiotics listed as being important for human medicine and formerly available over-the-counter (OTC), once more with attendant professional consequences for inappropriate prescriptions. Although the FDA issued the initiative as guidance, all relevant drug companies chose to impose a prescription requirement as a term of use for their antibiotic when marketing in the United States.

## What of demand for testing and professional services?

Animal species differ in regard to antibiotics requirements. Treated

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1. Throughout we use antibiotics, which treat bacterial infection, as the popular term understood to mean antimicrobials where in fact the latter category also includes viruses, parasites, and fungi. The legislation discussed in this article addresses the entire class of antimicrobials. Resistance development is a common concern across all damage-causing germs.

ruminants should not see disturbance to their gut bacteria needed for food digestion while dairy produce will be tested and discarded whenever significant amounts of antibiotics are detected. Antibiotics have been used to overcome the sanitary consequences of confined agriculture and so can be viewed as a component of confined animal farming systems, especially when buildings, logistics, and input sources compromise hygiene standards. Nonetheless, and following Jia, Hennessy, and Feng (2024), a stylized description of demand for antibiotics does admit a better understanding of how prescription regulations can affect demand for antibiotics and other inputs into animal production systems.

Figure 1 outlines the decision process countenanced by a herd owner. Leftmost starts with an animal that appears sick and may require antibiotics. The farmer has four choices: (a) call a veterinarian; (b) investigate independently through some self-administered test; (c) do nothing; or, (d) use OTC antibiotics. A self-administered test is the purchase of information about whether the situation merits antibiotics. This might be a mastitis test, of which there are several available, a pen-side respiratory disease test where many have recently become available (Puig et al. 2022), or just a costly private inquiry. Veterinarian services bundle this information (i.e., on what ails the animal) with access to solutions that might include antibiotics or involve other approaches. When available OTC, antibiotics may be directly chosen after private testing or chosen after calling a veterinarian. If the antibiotics are not effective one may need to call a veterinarian in any case even for a second time.

Prescription regulation simplifies the choice environment (see figure 2). Farmers must call a veterinarian before using antibiotics; that is, a farmer does

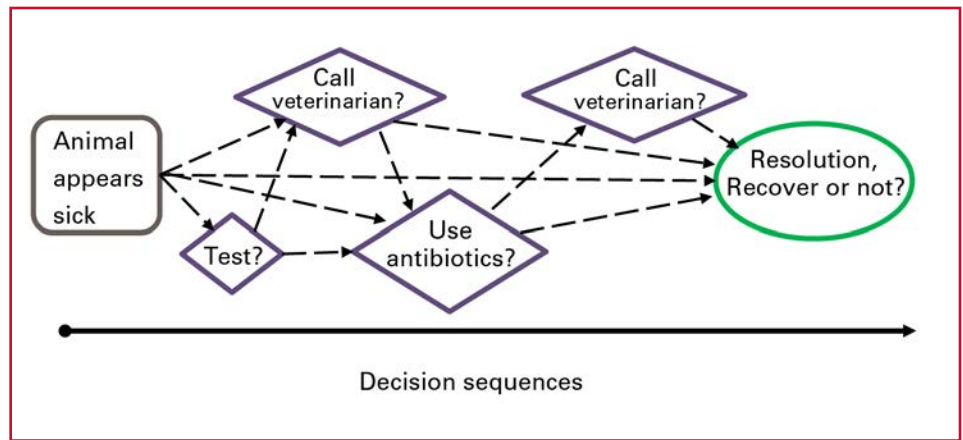


Figure 1. Information inputs into antibiotics choices.

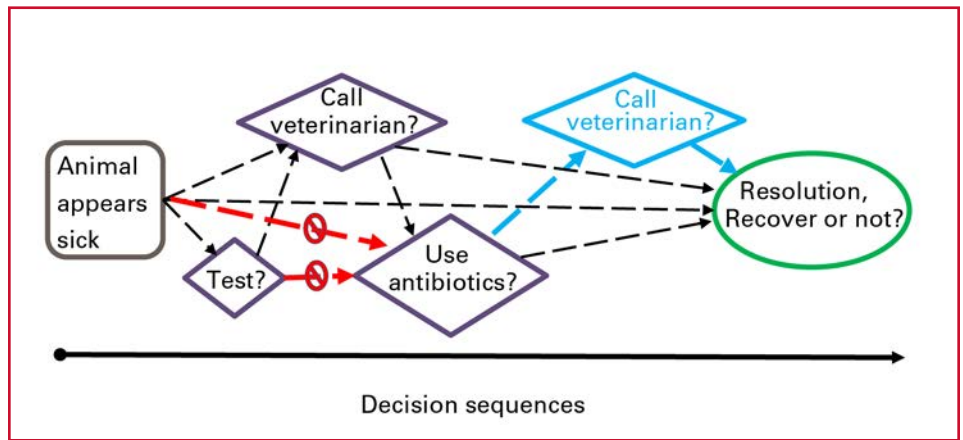


Figure 2. How PR affects information inputs into antibiotics choices.

not have the option to consider whether to use antibiotics or not before calling a veterinarian. In figure 2, the red arrows marked with a stop sign are no longer available options. Calling a veterinarian after using antibiotics becomes less relevant because one may already have called the veterinarian, which means the “Call veterinarian?” box on the top right of figure 2 is likely not needed. However, the four choices are interconnected when an animal appears sick, and so the PR policy that directly regulates antibiotics use will have impacts on other aspects of animal disease management.

PR will likely increase demand for veterinarian services (Tack et al. 2018) because the service is now necessary even when the farmer can independently establish the need for antibiotics or conclude that antibiotics are probably a profitable choice even when they are

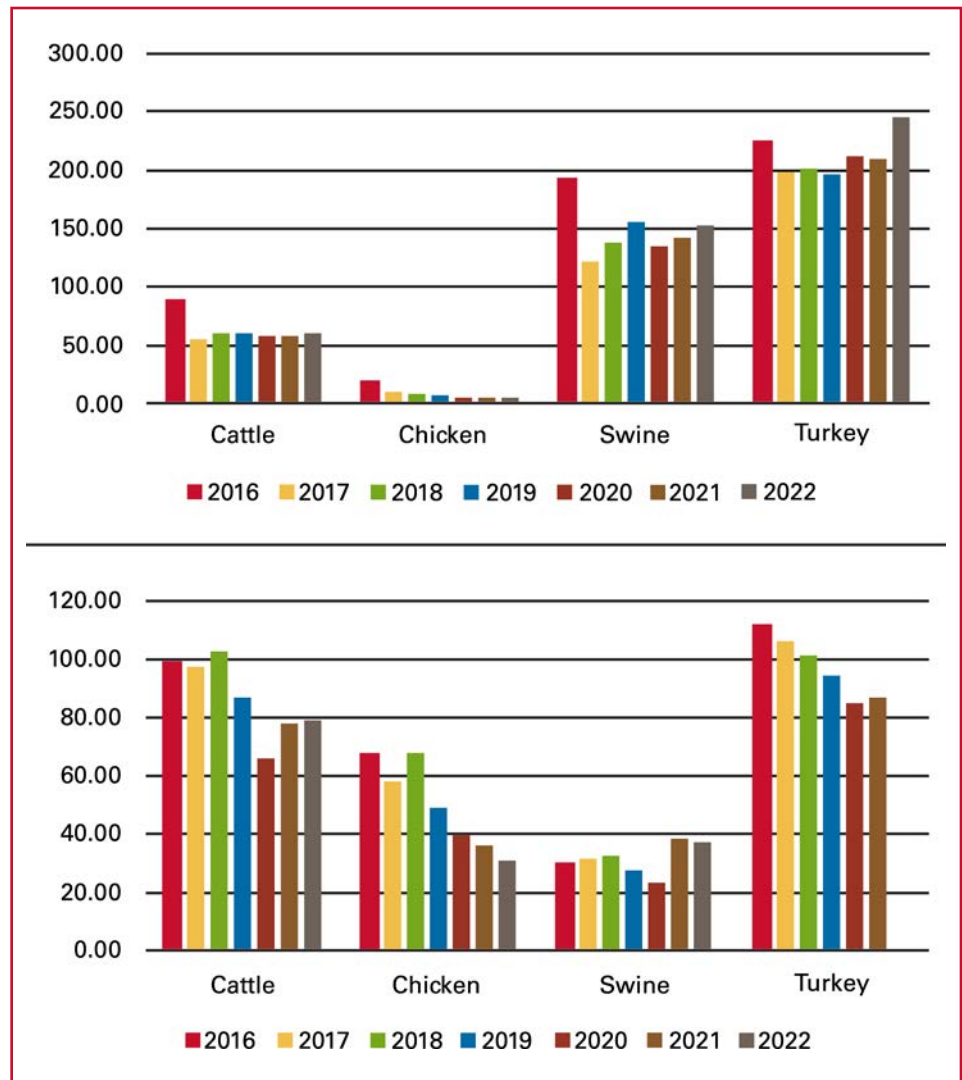
uncertain about their efficacy. The policy merit of PR is in ensuring a professional screen against: (a) uninformed use that may benefit the farm on-average; and, (b) use for proscribed purposes (i.e., for growth promotion). PR will also likely reduce demand for independent tests because accessing antibiotics involves buying a ‘test’ in any case, as embedded in veterinarian services. In order to comprehensively assess the effects of PR we will need to consider how PR affects the use of veterinarian services, self-tests, as well as changes in the quantity of antibiotics use. The costs of antibiotics and veterinarian services obviously are important decision factors as are the costs of testing, lost productivity from not applying treatment, marginal contribution to antibiotics resistance, the social costs of antibiotics resistance, and impacts on animal welfare.

## Regulation consequences and discussion

Given the broad and large risks of resistance development for society, the technical nature of diagnosis, and the low cost of generic antibiotics, the prima facie case for prescription regulation of antibiotics in agriculture is strong. Nonetheless, whether the means is effective in limiting veterinary antibiotics use to animals has not yet received the scrutiny it deserves; nor have the possible collateral consequences.

The upper panel in figure 3 reports the weight of antibiotics of importance to humans that were consumed per kilogram produced for different food animal species produced in the United States. Clearly the VFD legislation had an immediate short-term effect for cattle, swine, and chickens. Intensity of use for other antibiotics (lower panel) has also decreased as the food retail sector and farmers have responded to market and other pressures to remove where possible antibiotics from production systems. Usage in shorter-lived animals may become very low because for these animals there is less need for antibiotics to protect against damaged growth capacity. The regulations are evidently less burdensome for chickens than for other sectors. Complete removal of antibiotics from production systems is generally not feasible—the business model for organic herds is often to remove treated animals and market their produce as from a conventional herd.

The VCPR approach to ensuring that antibiotics are used only when necessary is decentralized in placing authority at or close to where knowledge of particular circumstances is greatest. An additional benefit for society as a whole and for the farming community at large is that VCPR strengthens channels whereby diseases that must be reported to authorities, including avian influenza, foot-and-mouth disease, African swine fever and many others, are more likely



**Figure 3. Biomass-adjusted medically important (top) and not medically important (bottom) antibiotic sales by year and species (mg/kg), 2016–2022.**

to be detected early when a veterinarian works closely with a farm enterprise. The matter is important because, and for a variety of reasons, the food-animal veterinarian workforce has declined dramatically in recent decades (Weltzien 2023).

However, the approach has many limitations. It favors larger farm enterprises because these enterprises can streamline the prescription acquisition process and also because business from these enterprises may be critical for veterinarian firm viability. It also creates incentives to circumvent the veterinary profession. The FDA Office of Criminal Investigations has

taken many actions against large-scale circumventions, including against Animal Health International in 2020, Midwest Veterinary Supply in 2023, and Covetrus in 2024. Finally, antibiotic resistance is a global problem so that this sort of regulation cannot be the only approach. These and similar regulations might make US animal protein production more competitive. However, if they contribute to driving meat production away from the United States toward countries that practice lower levels of antibiotics stewardship then selection pressure generating antibiotics resistance could increase. Finally, we should retain perspective by

considering PR and VFD as part of the whole tool kit that policymakers have. Other policy tools can induce lower antibiotics use, including taxing the use of antibiotics and subsidizing self-testing or veterinarian services. Weighing the tradeoffs between the intended and unintended consequences of each policy will help make for robust policies. The interested reader will find more detailed and technical analysis of prescription regulation as an approach to managing antibiotics in Jia et al. (2024).

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