December 2018

QUARTERLY U.S. RURAL ECONOMIC REVIEW

Agriculture Limps into 2019

This quarterly update is prepared by the Knowledge Exchange Division and covers the key industries served by CoBank, including the agricultural markets and the rural infrastructure industries.

Inside this Issue…

Key Points

- Ongoing trade disputes will continue to be the primary factor affecting agricultural supply chains in 2019. A new agreement with Mexico and Canada is not expected to be complete until mid-2019. Negotiations with China will not be resolved by the end of the 90-day period in March.
- The U.S. economy will sustain momentum entering 2019. However, rising interest rates, trade uncertainties, and a weakening global economy will drag on growth expectations.
- Abundant supplies of corn, wheat, and soybeans are weighing on prices amidst trade disputes. The U.S. soybean market continues to be profoundly affected by the loss of the China market.
- Compressed margins are forcing some ethanol plants to reduce production or close altogether.
- After experiencing growth for four years, the animal protein sector, particularly beef, will be put to the test in 2019 as exports slow and domestic supply grows.
- Persistent low milk prices are resulting in more U.S. dairy farms closing and herds being liquidated.
- While favorable weather helped many specialty crops flourish this year, natural disasters, product recalls, tariffs and disease are deeply impacting the industry.
- Outdated infrastructure replacements and droughts are combining to push rural water rates higher.
- The Federal Communications Commission is addressing shortfalls, bringing regulatory relief, and expanding satellite options in an effort to spur rural broadband expansion.

Executive Summary

Agriculture and its farmer cooperatives will face a challenging environment in 2019.

Commodity markets have steadied, but resolution of ongoing trade disputes and completion of recently concluded trade negotiations will be critical to restoring optimism for the year ahead.

U.S. and global economic growth will slow somewhat in 2019, but U.S. consumer demand will be supportive of the animal protein and dairy sectors. Uncertainties over trade flows and significant U.S. acreage shifts will complicate strategic business decisions in the crops sectors.

Continued increases in interest rates and the strong U.S dollar will add additional pressures. Sharp declines in farm income over the past few years have forced a drawdown of working capital in agriculture and an increase in debt levels. Financial conditions across commodities and regions remain highly variable.

Farmer cooperatives will have new challenges and opportunities as producers aggressively manage production expenses and actively seek productivity enhancements and marketing strategies in this difficult environment.

Global Economic Environment

The world economy is beginning to lose the broad-based economic momentum that began in 2017. While there are increasing downside risks to the global economy, growth is likely to remain in the 3 to 3.5 percent range in 2019 unless trade wars escalate.

The U.S. economy continues to benefit from strong consumer sentiment and rising business investment. Europe appears to be weakening in the face of reduced global trade and uncertainties over Brexit. Japan recorded negative growth in the third quarter of 2018, in part due to typhoon impacts. China has begun to add stimulus to its economy to maintain the desired 6.5 percent growth rate. Other advanced economies in Asia have remained steady, but concerns over China have limited optimism. Many of the emerging markets are struggling with currency volatility and sharply declining oil prices.

Key factors to watch:

- **Trade disputes.** The potential for ongoing and escalating trade disputes is the major concern in the near term. The U.S. imposition of tariffs, and the retaliatory actions by trading partners such as China, raise concerns for both short-term and long-term supply chain structures. The United States-Mexico-Canada Agreement (USMCA), which will replace the NAFTA agreement, was signed by all countries in late November. Legislative approval by all three countries may not be completed until mid-2019. The U.S. steel and aluminum tariffs on major trading partners and their retaliatory actions remain in place and are limiting traditional trade flows. The reopening of trade discussions with Europe and Japan have been positive actions, but any escalation in the trade dispute with China would impact growth expectations.
- **Economic momentum.** The U.S. economy has significant momentum entering into 2019. Consumer sentiment remains at record highs, and corporate profits should continue to boost business investment well into the new year. There are increasing concerns over the longer term as interest rates rise and the current business cycle reaches new records for longevity. One wildcard would be the economic response to the Federal Reserve commitment to moving interest rates higher. Equity markets have undergone a significant correction in late 2018. It's unclear how that might impact growth expectations.

- **China's growth.** China has made significant efforts to build a consumer sector to drive growth and reduce its reliance on business debt and net trade. Those efforts have made little progress, and policymakers are now resorting to monetary stimulus to achieve the desired 6.5 percent growth rate. Overcapacity in many industries and ongoing trade issues have impacted growth, resulting in the Chinese yuan declining significantly. Any escalation in trade disputes may force additional fiscal stimulus to maintain growth. Other Asian economies with close links to China are also impacted.

- **Brexit effect on European economy.** The European economy is expected to slow significantly in early 2019 as the negotiations over Brexit continue and trade issues limit export potential. A withdrawal agreement between the UK and the European Union (EU) has been reached, but British Parliament is far apart on its view of the deal. Adding to the uncertainty was Prime Minister Theresa May's narrow survival in a December 11 no-confidence vote triggered by those who oppose her compromise deal for exiting the E.U. A second referendum is becoming increasingly likely. Debt and fiscal issues among many Eurozone countries, such as Italy, remain an ongoing concern.

- **Currency volatility.** Economic weakness in Europe and Japan will likely mean that the divergence in central bank policies will widen into mid-2019 and result in continuing volatility in currency markets. The U.S. Federal Reserve increased rates in December and we expect it to do so twice more in 2019 unless the U.S. economy weakens. The European central bank and the Bank of England are likely on hold until mid-2019. This continuing policy divergence among central banks, coupled with strong U.S. growth relative to other major economies, will support the value of the U.S. dollar for the foreseeable future.

- **Cyberterrorism.** Cyberterrorism is becoming a significant risk to add to the list of geopolitical risks. Global attacks against information, computer systems, computer programs, and data are occurring at an increasing rate in both the private and public sector. These attacks are undermining public confidence.

- **Geopolitical disputes.** Geopolitical issues in Syria, Iran, Saudi Arabia, North Korea, and Russia will continue to add to global downside risks. The lack of any cohesive global leadership to deal with ongoing geopolitical disputes is one of the main threats to any renewed growth momentum.

U.S. Economic Environment

U.S. economic growth slowed in the fourth quarter of 2018, but the economy remained 3 percent above year-earlier levels. This represents the strongest growth since 2009.

Consumer spending and business investment have significant momentum heading into 2019. Quarterly growth rates in the year ahead are likely to be in the 2 to 2.5 percent range.

With unemployment rates at 50-year lows, job growth continuing strong, oil prices declining, and wage increases beginning to accelerate, the consumer remains a strong driver of growth well into 2019. Rising interest rates and increasing home values will pose an affordability issue for the housing sector, but other consumer categories should remain strong.

Corporate profits, boosted by solid consumer demand and tax cuts, remain strong and are currently 6 percent above year-earlier levels. That has fueled significant increases of nearly 8 percent in business fixed investment over the past year. While the rate of growth in profits will slow significantly in 2019, the level of profitability should continue to support investment, particularly if global uncertainties are reduced.

Trade uncertainties, rising interest rates, and domestic/global political developments will remain wildcards in the outlook.

U.S. Agricultural Markets

Commodity markets have steadied but remain focused on trade sector developments and the potential impacts of any slowing in global economic growth.

Southern Hemisphere crops seem likely to reach record levels, adding to the building surplus in the soybean sector. At the same time, stocks of coarse grains and cotton continue to decline and set the stage for major U.S. acreage reallocations among commodities in 2019/20. Wheat markets have improved as a result of smaller harvests in the former Soviet Union countries, but global stocks remain high.

Profit margins in the animal protein and dairy sectors remain under downward pressure as potential production increases are outpacing demand growth. Animal protein exports remain at record levels despite trade disputes. Dairy product exports remain firm and slightly above year-ago levels.

Financial conditions in agriculture will remain challenging in 2019. Net farm income is projected to decline by over 10 percent in 2018. It will likely be the lowest in over a decade.

Farm debt is rising as working capital is reduced and continuing increases in production expenses erode income potential. Significant acreage shifts among commodities may limit potential price increases in 2019, particularly if trade disputes continue well past midyear.

While the balance sheet of overall agriculture has been supported by firm land valuations, there remains a wide range of financial conditions by commodity and region. Hurricanes, tornadoes, flooding, drought, and wildfires have taken a significant toll on many commodities and regions of the country.

Grains, Oilseeds and Biofuels

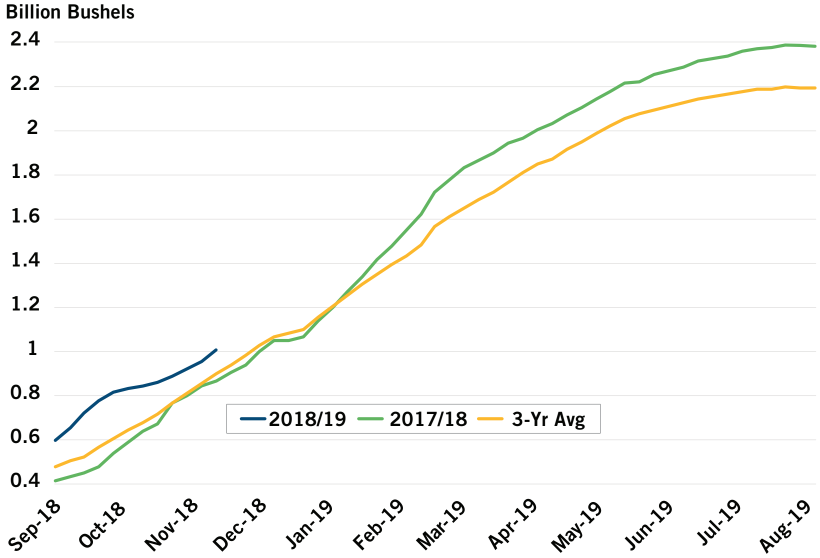
Fall harvest has wrapped up for nearly all of the U.S. Some areas in the Northern Plains and Western Corn Belt remain unharvested, but the bulk of the crop is out of the fields. Big production numbers are weighing on prices amidst the U.S.-China trade dispute.

Markets are now focusing on this marketing year's demand picture. Exports – or lack of – remain major drivers for corn, soybean, and wheat markets. Corn exports look strong, and wheat exports look to strengthen in the coming quarters.

In contrast, soybean exports will limp along as long as the U.S.-China trade dispute continues. The 90-day negotiation period agreed to by the U.S. and China is a positive development. The "very substantial" agricultural product purchases promised are still too vague at this stage to say things are turning around.

Even if the trade dispute is resolved, the U.S. export window is closing rapidly. Brazil will start shipping soybeans as early as the end of January, and China may have enough soybeans lined up for the coming months to get them through.

EXHIBIT 1: Total Export Commitments, Corn



Source: USDA-FAS; CoBank ACB

Domestic use is projected to rise YOY by around 2 percent. Much of this increase is expected through feed and residual since livestock numbers remain elevated going into 2019. The ethanol sector is projected to reduce corn use for the first time in over five years. Early indications suggest this forecast is on track.

Internationally, U.S. corn exports are stout. (*See Exhibit 1.*) Total export commitments are up 16 percent YOY. All four of the U.S.'s top four corn trading partners (Mexico, Japan, South Korea, and Colombia) have higher total commitments at this stage.

Next quarter will provide an early indication of 2019 planting decisions via the USDA. Their first estimate is due in February during their Agricultural Outlook Forum. The second follows in March in the survey-based Prospective Plantings report.

Corn area is widely expected to increase at least 2 million acres next spring. This is due to a reduction in soybean acres amid low soybean prices resulting from the U.S.-China trade dispute. These early estimates will impact commodity prices and set the stage for early estimates of the supply and demand balance for the 2019/20 marketing year.

U.S. soybean domestic crush is projected to be larger than exports for the first time since 2014/15 as domestic soybean processors respond to an elevated crush margin. Domestic demand will also be robust for corn as ethanol and feed and residual uses are projected higher this year, according to USDA. Domestic wheat consumption remains mostly flat.

Attention will quickly turn to South American crop sizes in the new year. Both soybean and corn production will likely increase year-over-year (YOY). Argentina is unlikely to experience a repeat drought. Brazil, which is expecting another record soybean crop, is more worrisome for U.S. farmers. The next quarter will provide initial indications of the crop's size and when it may start moving to port, filling China's import needs for another year.

Corn

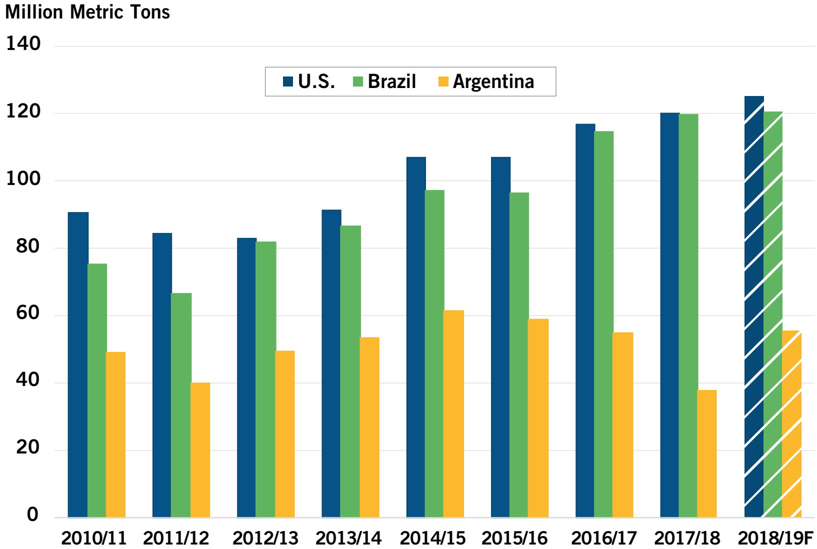
The 2018 U.S. corn harvest is largely complete after having dragged on over a number of weeks. Inclement weather dented yields, leading to higher harvest losses. USDA's projected average corn yield for 2018 was lowered in September, October and November, and now rests at 178.9 bushels per acre.

Soybeans

The soybean market continues to be dominated by the U.S.-China trade dispute, which has had profound impacts on trade flows, basis, carry in the futures market, and storage decisions. This will remain a key market factor in the quarter ahead.

Even if the trade dispute is resolved, the window for U.S. soybeans being shipped to China is closing fast. Brazil will likely start shipping soybeans by the end of January 2019. If China has enough soybeans in stocks or in transit, they may not purchase any U.S. soybeans

EXHIBIT 2: Soybean Production
U.S., Brazil, and Argentina



Source: USDA-FAS

Soybean domestic demand remains robust due to elevated crush margins, thanks to cheap soybeans. Soybean meal and oil exports will be key in the quarter ahead. Exports of both soy products increased in the first half of 2018 due to Argentina's drought-hit production. The rapid pace is widely expected to slow heading into 2019 amidst renewed competition from Argentina.

Weather has also been a complicating factor for the U.S. soybean harvest. While much of the soybean crop is out of the fields, some pockets of the country still have unharvested soybeans. Some fields will likely remain unharvested. Exactly how much and where will have localized impacts for elevators.

regardless of the tariff level. As a result, the hope for better export prospects and higher use would have to wait until the fall of 2019.

Soybean basis is weaker YoY because of both large U.S. production and the U.S.-China trade row. The dispute has disproportionately impacted basis in the Dakotas because soybeans from this region are typically destined for China via the Pacific Northwest.

Low soybean prices and high storage fees are prompting farmers to store as many soybeans on-farm as possible. This has forced elevators to walk a tightrope as they may narrow harvest basis to obtain more soybean ownership. These moves can be risky with basis appreciation expected to be limited this year.

Soybean trade with China has evaporated relative to last year. Recent purchases triggered by the Trump/Xi Buenos Aires meeting provide a glimmer of hope but not much more. Export commitments to China are still down more than 90 percent YOY. Other countries have taken up some of the slack. Export commitments to countries other than China have increased by more than 50 percent. They do not come close to fully replacing Chinese imports, however, resulting in total export commitments falling by more than 30 percent YOY.

Now that U.S. soybean production is largely set, the focus turns to South American production. (*See Exhibit 2.*) Brazil is projected to have an enormous soybean crop, thanks to more acres in soybean production and excellent weather. USDA projects Brazil's soybean production to hit 122 million metric tons (MT). Meanwhile, USDA's projected 55.5 million MT soybean crop in Argentina would be its third largest on record. Next quarter will provide significant information about the size of the South American crop and how early it will be harvested.

Wheat

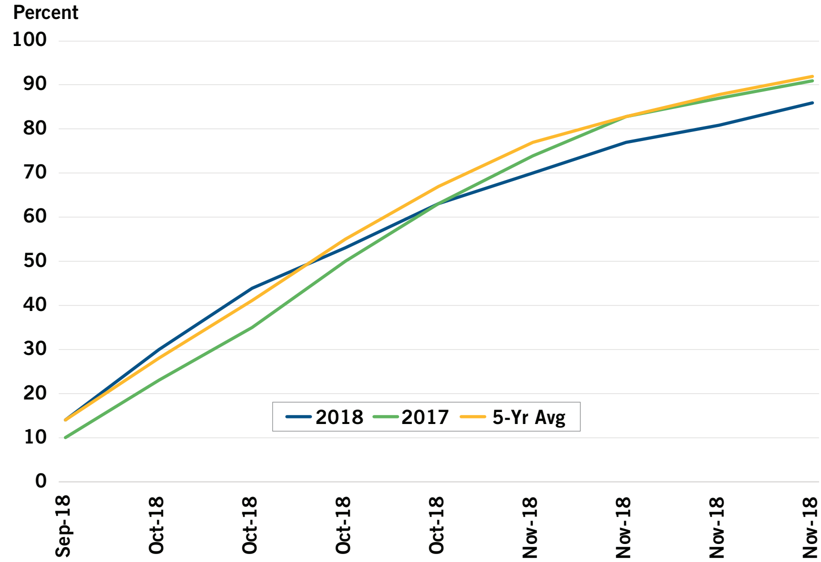
Wheat exports in the last quarter of 2018 still lag year-ago levels, but signs indicate improvement. Soft red winter and hard red spring wheat export commitments are now above year-ago levels after starting slowly. Hard red winter wheat export commitments still lag last year by around 30 percent.

The U.S. wheat export program looks to continue improving into 2019 amid crop concerns in major exporting countries. Wheat production suffered due to dry weather in key production regions, including the EU, Russia, Ukraine, and Australia. Export competitors will likely slow the pace of their export programs, providing an opportunity for U.S. wheat to be more competitive in the first part of 2019.

Meanwhile, wet weather this fall slowed and prevented some winter wheat planting in the U.S. This wet weather also forced some farmers to replant and has created emergence issues. (*See Exhibit 3.*) Despite these problems, over half of the winter wheat crop is in good or excellent condition. The impact of wet weather won't be fully known until the latter half of next quarter.

As a result of the winter dormancy, most of the focus in the next quarter will be on the initial estimate from USDA on planted winter wheat acres. The slow fall harvest and wet fall weather will be factors that have limited this year's winter wheat area. The January seedings report will better project supplies for the 2019/20 marketing year.

EXHIBIT 3: U.S. Winter Wheat Emergence

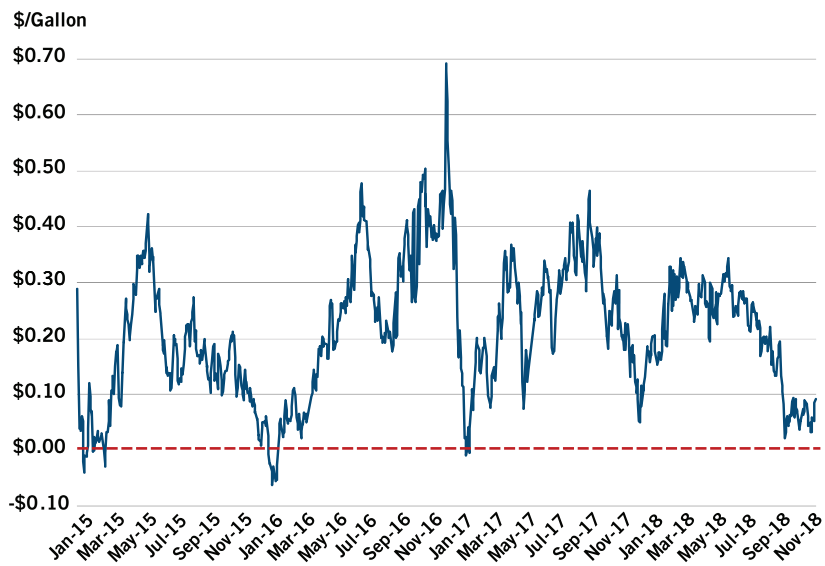


Source: USDA-NASS

Ethanol

Ethanol margins have continued their slide and are now near or below break-even levels for many ethanol producers. (*See Exhibit 4.*) According to Iowa State University's ethanol plant margin model, weekly operating margins have been below 25 cents per gallon since the start of August. Even worse, operating margins have been below 10 cents per gallon since the last week of September. Declining oil prices and relatively stable corn prices have been major drivers of this margin squeeze.

EXHIBIT 4: ISU Ethanol Plant Operating Margin



Source: ISU-CARD

In the face of these low margins, ethanol plants that face higher input or operating costs are at risk of mothballing or reducing production. Some companies are already halting production at select facilities. U.S. EIA data shows average weekly production is down industry-wide YOY for the four weeks ending December 7.

Margins for 2018/19 are shaping up to be very similar to 2015/16. In January 2016, average weekly operating margins were negative for three out of the four weeks. However, the rest of 2016 provided relatively solid margins for the industry.

In the next quarter, margins will help determine if profitability will follow the pattern in 2015/16 or remain depressed for a more extended period of time. One positive from low oil prices: It will likely reduce gasoline prices in the months ahead. This, in turn, will stimulate more gasoline consumption during the travel season and stimulate ethanol consumption.

Additional demand may come from exports. Exports have started the marketing year better YOY. September exports were nearly 4 percent higher. However, Brazil's new president is seeking to boost their domestic ethanol industry. After being elected in late October, he has stated Brazil should be the global leader in ethanol production. If realized, this would create headwinds for the U.S. ethanol export program. Brazil was the chief importer of U.S. ethanol at over 470 million gallons last year – over 40 percent more than Canada, the second largest importer.

On the policy front, the EPA has released its final 2019 renewable fuel blending mandate. The 2019 mandate increases total volumes by 3 percent over 2018. Conventional biofuel remains flat at 15 billion gallons. The EPA also released its 2020 volume requirements for biomass-based diesel, increasing it to 2.43 billion gallons. Two questions remain.

- What impacts will continued use of the small refinery exemption and the eventual introduction of E-15 blends have on domestic consumption?
- How will the EPA adjust mandated volumes in 2020-2022 now that renewable fuel mandated levels are less than 80 percent of statutory levels for two consecutive years (2018 & 2019)?

Farm Supply

Inclement field weather across the Midwest and a slow harvest have negatively impacted fall fertilizer applications, reducing fall revenue for some agronomy departments and farm supply cooperatives. However, this likely means more applications will be squeezed into the spring application season, putting pressure on labor costs. A compounding factor is that farmers may be forced to push fall fieldwork into the spring, further compressing the spring fertilizer application window. These consequences will start to hit at the end of next quarter.

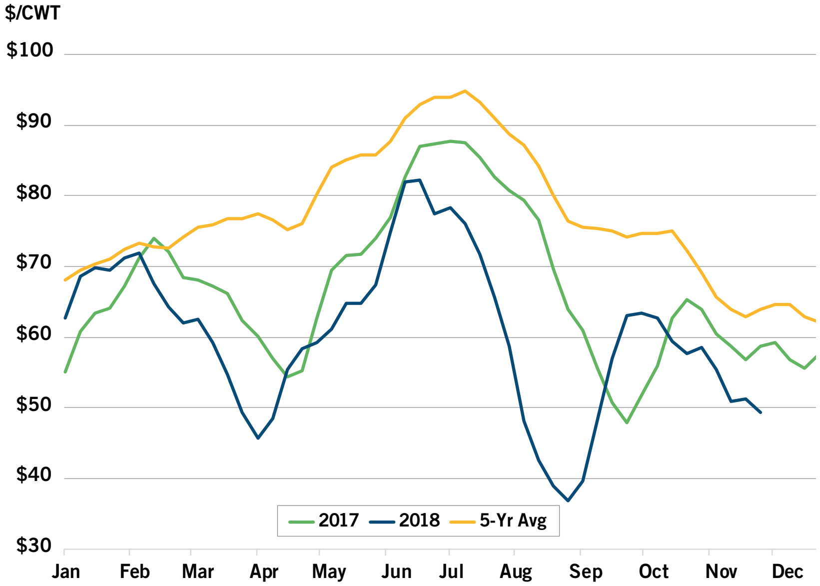
Amid these fieldwork delays, urea and phosphate prices weakened slightly. In contrast, potash prices moved higher on tighter supplies. With demand just delayed and not destroyed, fertilizer prices are widely expected to move higher toward the end of next quarter as spring applications begin. Nitrogen fertilizer prices, in particular, will be additionally supported by the expectation of higher corn acres in 2019.

Crop protection products were impacted by the most recent tariffs imposed on China. All formulated crop protection chemicals were hit with a 10 percent tariff. Active ingredients were also included in the most recent tariffs, but several key active ingredients have been exempted. These include dicamba, glyphosate, and glufosinate.

The 10 percent tariff is painful, but it can be absorbed by many suppliers or importers. A tariff hike to 25 percent in March 2019 would create major changes in the crop protection supply chain, however. Importers would likely seek out alternative suppliers in other countries, try to import exempted active ingredients instead of formulations and find a company to formulate in the U.S., or try to raise prices to purchasers down the supply chain.

The 90-day U.S.-China negotiation window delayed the potential for a tariff increase. This makes it possible for importers to build sufficient seasonal inventories under the 10- percent tariff. As a result, farmers should not see a major price change this year.

EXHIBIT 5: Carcass Base Price, IA - So. MN



Source: EUSDA-AMS

While profitability in the beef complex remains quite strong and the cattle herd shows signs of peaking in early 2019, poultry supply is marching ahead. A half dozen poultry plants will come online in the next 18 months, bringing a double-digit increase in capacity. With it comes the need for rational supply responses by other producers. This is also necessary in the pork sector, which is also seeing a challenging supply/demand environment.

The animal protein industry has seen robust growth for nearly four years. 2019 will test whether producers will respond to the market as margins come under pressure.

The U.S. animal protein sector has endured significant volatility in the final quarter of 2018. Trade disputes that have affected animal protein exports, most notably pork, involve a number of the industry's most important export partners. Nonetheless, U.S. protein exports grew in 2018, including double-digit growth in beef exports. Strong domestic economic growth helped to absorb supply growth from all three major proteins, especially demand in foodservice that is key to beef and poultry profitability. This rate of economic growth is expected to slow in 2019, which will have disparate impacts on each protein species. Beef is the most at risk from a slowing economy, not only because of its historical premium price to other proteins, but also because those premiums reached historic highs in 2018.

Animal Protein

Protein supply will continue its four-year expansion in 2019, albeit at the slowest rate since 2014.

Pork supply growth will lead the sector as new plants, extended shifts, and the hope of increased trade opportunities with China drive producer optimism. Beef and poultry will follow.

Pork

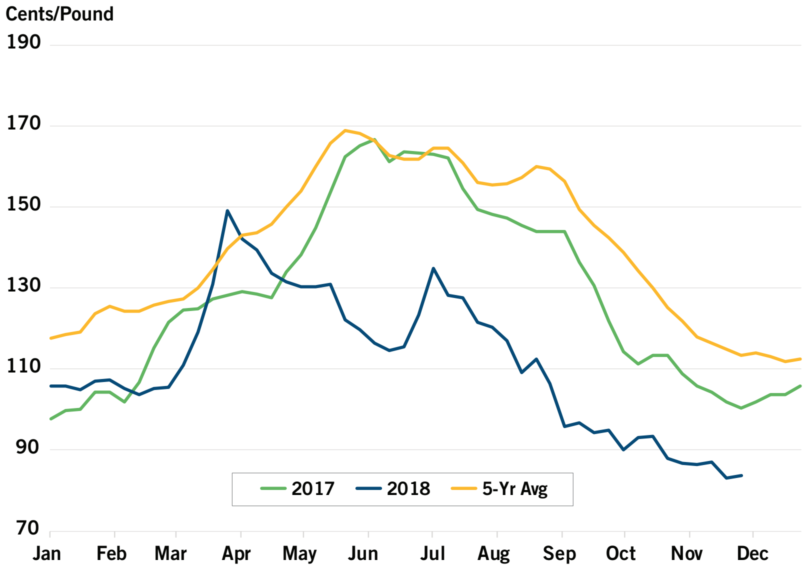
Hog prices continued to endure a high degree of price volatility in fourth quarter 2018. The market was whipsawed by trade concerns with China and Mexico and the outbreak of African Swing Fever (ASF) in China and Belgium.

Prices started the third quarter at $78 per cwt on a carcass weight basis. They fell precipitously through July and August, breaking below the $40 level for the first time in 15 years. But then, prices rapidly climbed to over $60 in the months following before settling near the current $50. (*See Exhibit 5.*) These issues are expected to keep the hog market in a state of high volatility into 2019.

In early July, Mexico increased its tariff on U.S. pork to 20 percent. This is driving substantial losses for U.S. hog producers even though Mexico remains the number one importer of U.S. pork.

These challenges helped the U.S., Mexico and Canada agree to the USMCA free trade agreement. The agreement outlines tariff-free access for U.S. pork to Mexico, however the 20 percent Mexican tariff will continue as long as the U.S. maintains its tariffs on Mexican steel and aluminum. Exports in the last quarter saw both a lower export pace and lower prices.

EXHIBIT 6: Boneless Skinless Breast Price



Source: USDA-AMS

Pork production was also disrupted by two hurricanes in the southeastern U.S. The storms shut down pork plants in North Carolina and drove prices higher in the second half of September. Since then, a good deal of that production has now moved in to the fourth quarter.

Pork production is expected to climb by 4 to 5 percent in the fourth quarter, up from just over one percent in the third quarter. This will likely continue to put pressure on hog prices heading into 2019.

The outbreak of ASF in China that started making headlines in early September has steadily spread to nearly every major hog-producing province in China. With it comes optimism of increased pork trade to fill what will very likely be a supply gap. While the virus has spread rapidly the last few months, its impact on U.S. exports has been relatively small. It could have a bigger influence in 2019, however.

The industry is still optimistic about trade opportunities and will continue to expand output in 2019. Growth expectations range from 2 to 2.5 percent, down from 3 to 3.5 percent in 2018.

Chicken

The U.S. chicken sector continues to battle for space in the meat case with the struggle yielding persistently lower chicken prices. Skinless boneless breast meat prices, which have long been the bellwether for chicken producers, fell to nearly 80 cents per pound in late November – the lowest on record and nearly 20 percent lower YOY. (*See Exhibit 6.*) Profit margins for producers have been in the red since the third quarter, which will likely continue through early 2019.

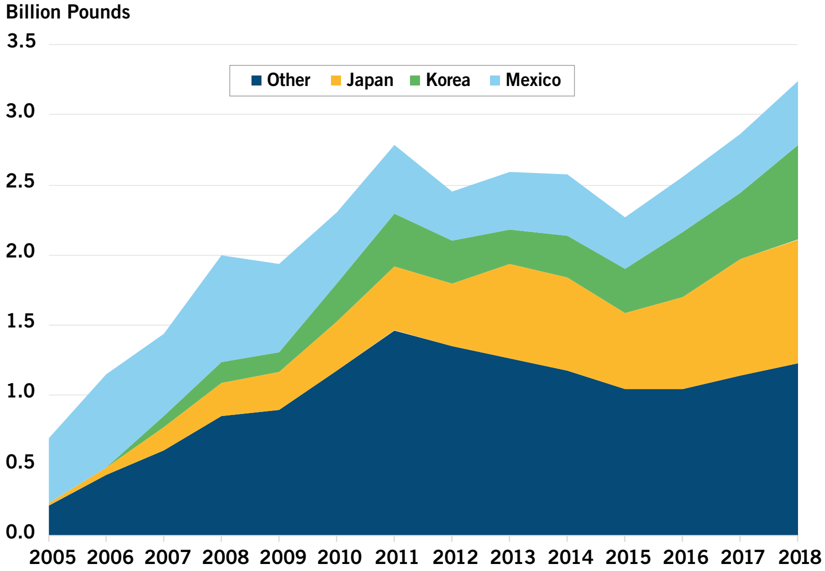
Chicken production is widely thought to be outpacing pork and beef, but is in fact growing more slowly than its protein competitors. Retail featuring for chicken has declined since last year while beef and pork has increased. This is likely the result of increased consumer spending and consumers' willingness to spend on more expensive animal protein offerings than chicken. This dynamic will likely remain in 2019 since pork and beef supply growth is expected to continue to outpace chicken.

Export growth has been less than 2 percent, which is a far cry from the nearly 5 percent growth for pork exports and 10-plus percent growth for beef. U.S. poultry exports have been helped by the U.S.-Mexico tariff on pork and have grown 6.5 percent year-to-date (YTD). Exports to the Middle East and the former Soviet Union countries, though, have struggled.

Supply growth for 2018 is figured at 2.5 percent and will continue in 2019 in light of the six new poultry plants coming online over the next 18 months. These plants have the capacity to increase U.S. chicken supply by 9 percent by 2020. But given the current weakness in U.S. chicken prices, other plants will likely slow production.

A key concern of industry participants this year has been the lack of available labor. As new chicken plants come online in 2019, some producers will likely take a closer look at reducing lines if not shuttering plants entirely due to labor scarcity.

EXHIBIT 7: U.S. Beef Exports



Source: USDA-FAS

Trade will be of increasing importance for the U.S., with beef production expected to increase 2 to 2.5 percent in 2019.

Beef demand remains strong at both retail and foodservice, driven by robust featuring activity and strong consumer optimism. Upbeat consumers have kept beef prices high relative to pork and poultry. The comparative price premium of beef has hovered at all-time highs, meanwhile pork and poultry prices have declined.

A U.S. economic recession appears more likely by late 2019 or 2020. This represents a growing risk to the beef complex given its premium price point and reliance on a strong U.S. economy.

Despite hurdles, chicken production is expected to increase by 2 percent in 2019. The vast majority of the growth will come from increased bird numbers.

Beef

The U.S. beef sector is heading into 2019 on strong fundamentals. Fed cattle prices were resilient through the fall and beef demand at retail has been some of the best in years. Further, 2018 will be the third consecutive year of double-digit export growth. Concerns are growing, though, amidst continual increases in total animal protein supply and questions about the economic outlook.

The importance of exports on the beef complex cannot be overstated. (See Exhibit 7.) Since 2015, U.S. beef exports have grown by over 10 percent annually. They are expected to be nearly 40 percent higher by the end of 2018.

In the third quarter this year, beef exports surpassed 12 percent of production for the first time in industry history. Nearly three-quarters of this growth has been to Korea and Japan, but with the new Comprehensive and Progressive Agreement for Trans-Pacific Partnership increasing Australian beef export competitiveness, the U.S. position in the Japanese beef trade is in question.

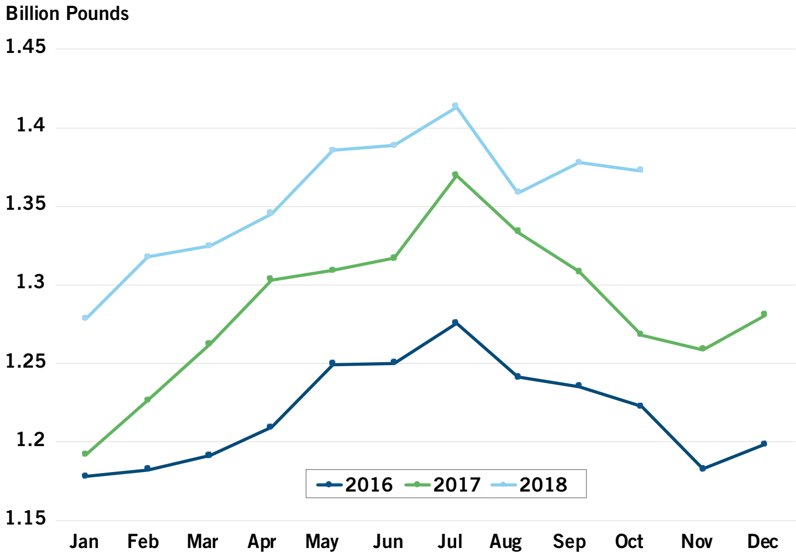
Dairy

The dairy production sector remains under extreme pressure. Farms are closing and herds are being liquidated. Slaughter rates are the highest since 1986 when there was a government-sponsored herd buyout program in effect. Low milk prices are challenging enough, but cull cow revenue is negligible and replacement heifers are cheap and available but not moving. These all highlight the fact that milking cows is a tough business to be in right now.

Herd numbers down/production up. The national dairy herd lost 30,000 head in October compared to a year ago and currently stands at 9.37 million. Still, despite fewer cows, 0.8 percent more milk was produced due to efficiency gains. These efficiency gains rather than a growing number of cows continue to be the dominant driver of milk production.

Cheese inventory climbs/low prices continue. Cheese markets are down from their peak in September. The spread between block cheddar cheese prices and barrel cheese prices has been volatile. For several weeks, barrel prices were significantly less than block prices.

EXHIBIT 8: Total Natural Cheese Stocks in Cold Storage



Source: USDA-NASS

More block cheddar manufacturing capacity – including a new cheese plant being built in Michigan – is coming online in the future. This should increase the supply of block-style cheddar. Also, the general milk supply situation should tighten in the upper Midwest where discount milk has been flowing into barrel cheddar production lines.

Heavy cheese inventories are a major contributing factor to the downward price pressure that will push through the end of the year. Total cheese inventories in cold storage on October 31 were up 8 percent YOY. (*See Exhibit 8.*) More recent reports, however, indicate that these low prices have spurred strong sales and good order volume, including from Mexican buyers despite continued tariffs.

Butter market is calm. Butter prices have been relatively range-bound around $2.30 most of this year. There is no major reason to expect much different in 2019. Inventories are in-line with seasonal norms and should begin building once holiday orders are out the door. Demand continues to be strong overall for butter, but the growth rate experienced over the past few years has likely plateaued for now.

Whey and nonfat dry milk orders strong. Prices for whey and nonfat dry milk gradually declined through 2017, then gradually climbed through 2018. Whether this wave pattern continues and we see price declines in 2019 remains to be seen. For now, however, orders seem strong – particularly for milk powder exports to Mexico.

Whey exports to China are starting to take a hit due to tariffs. They are down 13 percent YOY in September and have decreased 22 percent from a month earlier. Year-to-date exports to all destinations, however, are still up 13 percent this year.

All-milk price improvements expected. The all-milk price has likely already put in its peak for the year in the most recently released October value of $17.40 per cwt. Prices are expected to improve in 2019, which is expected to bolster farm margins if feed costs remain stable.

Other Crops

Cotton

Weather dealt a blow across many of the cotton-growing regions just ahead of harvest. Georgia received the worst of it with Hurricane Michael hitting the crop just as most bolls were open but not yet harvested. Damage to the crop was estimated at $300 million to $800 million. Other areas of the Southeast, while not hit as directly as Georgia, still suffered from late wet weather, which will have a negative impact on quality.

Total production is estimated most recently at 18.41 million bales this year, a downward revision reflecting the damage in the Southeast. This is a decrease of nearly 12 percent from last year, despite the higher initial acreage planted. Higher beginning stocks this year should offset this decrease and result in a similar starting point to last year.

The U.S.-China trade dispute continues to cause turmoil in the global cotton trade. The ongoing trade war and associated tariffs were initially discounted by markets. The assumption was that either the dispute would be resolved quickly or the desire for U.S. cotton from China would be too strong. But as the dispute lingers and teeters on further escalation, market risk remains elevated.

Rice

The U.S. rice crop is harvested, and total production is expected to be up 23 percent YOY. The increase was driven by substantial area increases, which were almost 20 percent on average. All states reported increased acreage. Yields are generally steady to slightly lower in most areas. Imports are up, largely as a result of a sale from China to Puerto Rico.

Global demand is expected to continue to grow, though on a per capita basis consumption is generally down. The major exception is Sub-Saharan Africa where demand growth is around 4 percent compared to population growth of 2.5 percent. Continuing to participate in global markets and grow export market share will be important for the industry heading into 2019.

Larger supplies in the 2018/19 season should pull prices down slightly and narrow the price gap between the U.S. and the rest of the world. This is expected to strengthen exports by 10 percent.

Exports to Iraq continue to show strength and reflect challenges in the region, particularly in Egypt. Dry weather and water restrictions have taken Egypt out of the global export picture.

Sugar

The 2017/18 sugar year wrapped up at the end of September. Production got an extra boost from this year's early cane season harvest, bringing estimates up to approximately 9.3 million short tons raw value (up 3.6 percent YOY). Meanwhile, total imports were also up and domestic deliveries were down, leading to further expansion of ending stocks and ample supplies coming into 2018/19.

The story is similar in the global sugar market. World ending stocks for 2017/18 were up 18 percent YOY, which put downward pressure on world sugar prices. While U.S. sugar policy generally insulates the U.S. from world sugar prices, there is concern that these low world prices may afford greater economic opportunity for imports to enter at the higher duty rates.

Partially offsetting the growing global sugar supplies is the reduction expected this year in Brazil. Dry weather conditions combined with economics, which are driving a greater proportion of sugar into ethanol, are reducing the country's exports. Additionally, according to a recent Bloomberg survey, production in India – poised to soon surpass Brazil in sugar production – may be less than initially expected due to dry weather and pest issues.

Despite the decline in 2017/18 domestic consumption, population growth will continue to fuel demand growth in years ahead. However, the rate of growth is slowing as per capita consumption continues to decline.

The latest USDA projections for 2018/19 sugar production (YOY) are:

- Beet sugar – down 5.8 percent.
- Cane sugar – up 0.7 percent.
- Total sugar – down 3.0 percent.

Recently, 2018/19 beet sugar production forecasts have been reduced relative to earlier estimates. This is due to unusually cold October weather in the Minnesota and North Dakota region. The cold weather slowed harvest and has the potential to negatively impact the quality of beets being piled for winter slicing. However, it is too early to know for certain the impact this early cold spell will have.

The beet and raw sugar market dynamics noted above support USDA projections calling for 2018/19 cane refiner margins to be in line with 2017/18.

Specialty Crops

For many of the specialty crops, favorable weather has set up the 2018/19 crop year with YOY production growth. However, natural disasters, retaliatory tariffs, and food safety issues have impacted specific crops and regions to varying degrees.

Hurricane decimates pecan crop. Hurricane Michael hit Georgia's core pecan production region resulting in what is being called the largest global pecan crop loss in history. Statewide, Georgia's pecan crop is expected to be down roughly 50 percent, according to an assessment by University of Georgia Extension.

However, specialty crop losses extend well beyond just Georgia pecans, as noted in the table below.

Wildfires taint grapes. Wildfires have burned approximately 1.67 million acres YTD in California, according to statistics from Cal Fire and the National Interagency Fire Center. That's up from 1.27 million acres in 2017.

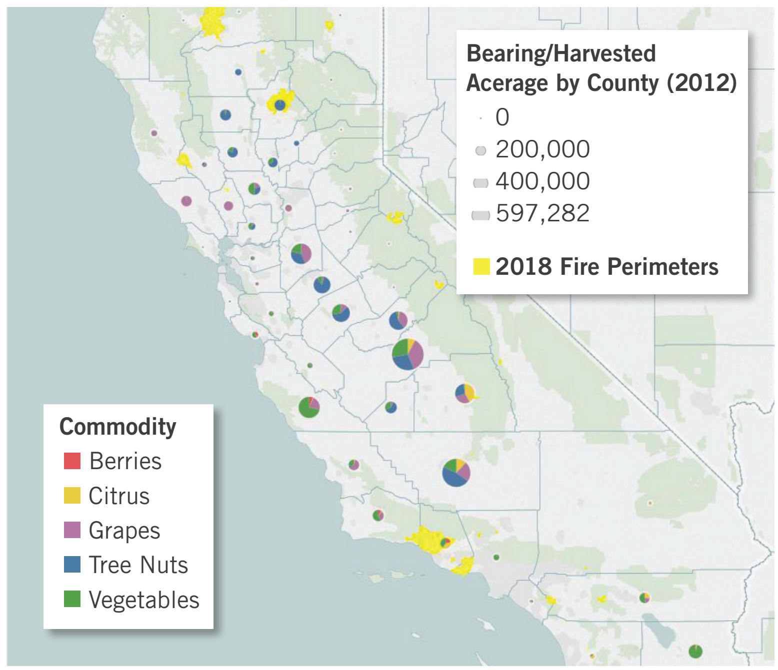
EXHIBIT 9: Impact of 2018 Hurricanes on Florida and Georgia Specialty Crops

Key Specialty Crops Impacted	Estimated Value Loss from Florence and Michael	Value Loss as Percent of 2017 GA & FL Crop Values
Vegetables and Melons	$488.8 million	28%
Fruits and Tree Nuts	$567.7 million	29%
Peanuts	$34 million	4%

*Not included in these estimates are the significant losses yet to be released/estimated by North Carolina and South Carolina.

Source: University of Georgia Extension, University of Florida-IFAS, CoBank

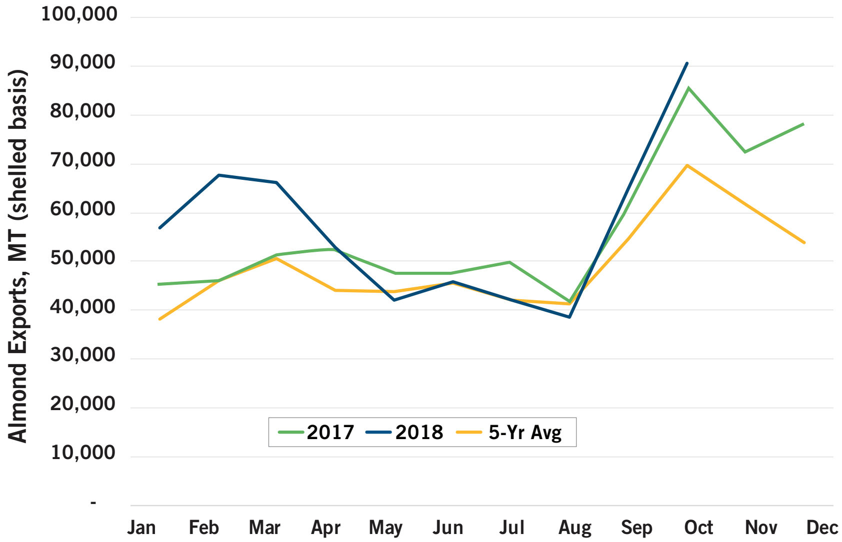
EXHIBIT 10: California Fire Perimeters and Acreage of Key Specialty Crops



Source: Cal Fire, USDA-NASS, CoBank

The total cropland impact has not yet been fully accounted for. Of note are 200 acres of vineyards along the Malibu coast that were largely decimated by the fires. Other core specialty crop production areas have been largely spared from the fires. However, the potential impact on tree nuts in Butte County and vegetables and citrus in Ventura County will be worth monitoring as more information is made available. (*See Exhibit 10.*)

EXHIBIT 11: U.S. Almond Exports, Shelled Basis



Source: USDA-NASS

Smoke taint for table and wine grapes remains a concern in key production areas. Wine grape growers in California's Lake County alone have reported a $37.1 million loss due to smoke taint.

Exports are sluggish. Exports have been sluggish across many of the specialty crop sectors as a result of increased tariffs with key U.S. trading partners. YTD wine exports have been holding relatively steady compared to 2017 volumes, but export values have plummeted over the last couple of months.

Tree Nuts

Almonds. Robust supplies and weak demand can be expected to put downward pressure on 2018/19 prices. However, low 2017/18 ending stocks will help to moderate this downward pressure.

Continued acreage expansion drove 2018 almond production to a record 2.3 billion pounds this fall, up 6 percent YOY. While domestic demand remains strong, the pace of almond exports has plummeted amidst the ongoing trade war. In turn, supplies have swelled and prices have slumped.

China, Turkey, and India have all increased tariffs on U.S. almonds in response to steel and aluminum tariffs. Almond exports were well above the five-year average pace early in the year but dropped below this pace in the spring as retaliatory tariffs started to take effect. (*See Exhibit 11.*) Fears of yield impacts from frost earlier in the season also kept prices firm and trimmed demand, while production expectations in key destination countries, such as the EU, increased.

USDA's latest projection calls for a 2 percent increase YOY for the 2018/19 crop year, due primarily to growing shipments to the EU, Japan, and the Middle East. While the pace of exports has recovered in the last two months, this projection will depend on whether this recovery can be sustained.

Pecans. Hurricane Michael decimated Georgia's core pecan production region in October. Statewide, Georgia's pecan crop is expected to be down roughly by half, which is notable considering Georgia is the largest pecan-producing state, accounting for over a third of U.S. production.

Making matters worse, the damage done to older, productive trees could take years to recover. Production in Central Texas is also reported to be down despite earlier expectations of it being a strong season for the Texas crop.

Pecan exports are up 12 percent YOY despite the 27 percent decline in shipments to China. However, net exports are down due to large import volumes from Mexico.

Greater price volatility and overall lower YOY pecan prices have resulted from:

- 47 percent tariff China has placed on U.S. pecans.
- Quality differences resulting from hurricane damage.
- Rise in Mexican imports.
- High 2017/18 ending stocks.

Nonetheless, with the dramatic cuts to 2018 production, upward price pressure is expected as the marketing year progresses.

Walnuts. Slow export demand, relatively high 2017/18 ending stocks, and a big – if not record-breaking – crop have combined to put strong downward price pressure on walnuts. This is widely expected to persist through most of 2019.

Though August USDA production forecasts call for record-breaking walnut production, recent yields have come in lower than expected. In August, the National Agricultural Statistics Service forecasted 2018/19 walnut production at 1.38 billion pounds, just over the previous record crop of 2016/17 and 10 percent over 2017/18. This boost in output is the result of increases in both yield and acreage, with acreage reaching a record-breaking 350,000 bearing acres. However, grower reports in late October revealed yields below USDA expectations.

Weaker exports have been a persistent concern this year. However, signs point to a slowing in the rate of decline. Key 2018 YTD export increases have been to Europe and Turkey. Key decreases have been to China and India, which follow increased import tariffs.

Pistachios. While domestic demand for pistachios remains strong, ample supplies and potentially softening export demand have weakened 2018/19 price expectations. Reductions in 2017/18 ending stocks will help moderate these downward price pressures.

Pistachio acreage is at a record level. With harvest complete, farmers are reporting robust yields and good quality. The American Pistachio Growers estimates an 850 million- to 950 million-pound pistachio crop. It could beat the record 896.5 million-pound crop set in 2016.

The 2017/18 exports were down 23 percent relative to 2016/17, which may have been as much a reflection of reduced supplies as actual demand reduction. The 2017/18 crop was down 49 percent relative to the strong 2016 crop. Meanwhile, despite reduced supplies, 2017/18 domestic usage held strong, according to USDA.

Grapes

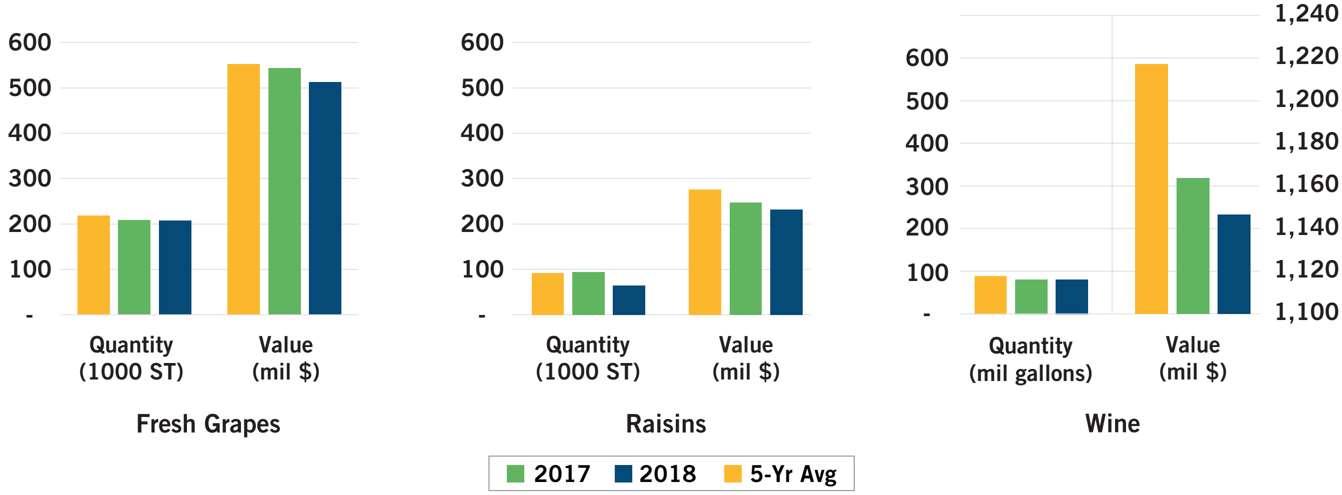
With harvest largely wrapped up, USDA's latest 2018 grape production estimates are coming in at 7.7 billion tons, up 4 percent YOY. The hike is driven mostly by productivity increases since acreage has remained relatively stable.

No major change in acreage is expected in 2019 since growers have been planting at attrition rates for the last three years. There are regional exceptions, however. In particular, Central Valley California growers are feeling margin pressure resulting from high supplies and relatively weak export demand. This, along with water limitations, means tree nuts and other high-value crops are displacing wine acres in some areas.

Additionally, while the final impact of the California wildfires is yet to be determined, there are areas that have been deeply impacted. Two hundred acres of vineyards on the Malibu coast have been largely decimated and other areas were also impacted. The California wine industry is currently seeking national disaster assistance.

YTD exports are down relative to 2017 and the five-year average for both fresh grapes and raisins. On the other hand, wine exports have been holding near 2017 levels. While raisin exports have taken a large hit, the decline is in line with the reduced 2017 production. (See *Exhibit 12.*)

EXHIBIT 12: U.S. Exports of Fresh Grapes, Raisins and Wine (Jan-Oct)



Source: USDA-FAS

This year's grape harvest is generally expected to be high quality. However, smoke taint is a key issue in California production areas where wildfires occurred at veraison. In Lake County, growers reported a $37.1 million (about 44 percent of county grape value) loss this year from smoke taint. Estimates are pending for Mendocino County where significant losses from smoke taint are also reported.

A record raisin price has been set for the 2018 crop, but there is concern regarding the impact on domestic demand and global competitiveness. Raisin stocks are reportedly down an estimated 45 percent YOY and the Raisin Bargaining Association has set this year's raisin price at a record level.

Proponents say the higher price is needed to offset rising costs and to keep growers from switching to other high-value crops. Sun-Maid, the sole packer that did not sign the agreement, has raised concerns over import competitiveness and demand implications.

Price hike opponents are concerned that the higher prices will erode domestic demand, and the large global supplies will put downward pressure on world prices. This could open the door for greater imports from competitors such as Turkey. Due to domestic supply reductions, YTD raisin imports are up 238 percent (54,000 short tons) YOY.

Other Key Specialty Crops

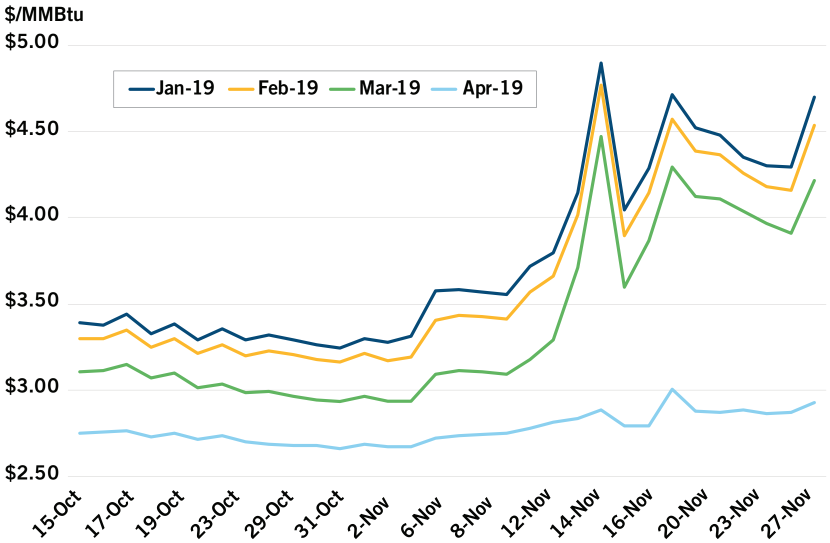
Avocados. The avocado strike that prevented imports starting October 29 was lifted on November 14. The strike ended just as reports indicated that supplies were dwindling such that consumers would have begun to notice an absence in their grocery store shelves by the end of November.

Citrus. As profiled in a KED citrus report released earlier this fall, juicing orange production continues to fall as the industry struggles with citrus greening. Oranges account for roughly 74 percent of bearing citrus acreage. Similarly, lemons, grapefruits, and tangerines also showed continued reductions in production.

As the 2018/19 crop year starts off, USDA's November forecast projects a 39 percent increase in orange production relative to hurricane-impacted 2017/18 and an 8 percent increase over 2016/17. On the other hand, 2018/19 grapefruit, tangerine, and tangelo production are forecasted slightly below 2016/17 levels.

Cranberries. USDA has authorized 25 percent of the 2018/19 cranberry crop to be withheld from the market. The withheld produce will be diverted to fertilizer, animal feed, or donations to protect grower prices from the impacts of surplus supplies.

EXHIBIT 13: Henry Hub Futures Contracts by Settlement Month



Source: ABB Velocity Suite

Lettuce/Leafy Greens. Just as the romaine lettuce industry was still working to rebuild consumer confidence after the E.coli outbreak in the spring, a second blow to the industry came in November. The CDC released a statement on November 20 recalling all romaine lettuce and urging consumers to throw away any unused romaine.

The recall was partially lifted on November 26 for lettuce grown outside of the California Central Coast growing regions after the FDA and industry representatives reached an agreement on voluntary labeling going forward. Consumer were given the green light to consume romaine if:

- It was grown in an area outside of where the outbreak is suspected to have originated.
- It is hydroponically or greenhouse grown.

While the depth and longevity of the resulting demand impact is difficult to predict, these things are for certain:

1. There will be volume demand and price reductions across the romaine and leafy green markets.
2. This will not be a short-term shock to the market. It will take time to rebuild consumer confidence and restore demand. Several months after the previous recall, it was reported that romaine lettuce sales were still down 25-40 percent from year-prior levels.
3. This event has only fueled the fire for additional food safety protocols and traceability capabilities (including but not limited to blockchain development).

Blueberries. Pollination problems resulting from unfavorable and volatile weather have resulted in the smallest Michigan blueberry crop since 2005. It is down 33 percent from the 10-year average.

Infrastructure Industries

Power and Energy

Low natural gas inventories combined with strong demand and abnormally cold weather reintroduced volatility to U.S. natural gas prices this quarter.

Elevated prices have been fueled in part by rapid growth in demand for natural gas from sectors that are less sensitive to price changes. (*See Exhibit 13.*) Inelastic demand is expected to ratchet prices higher during peak winter demand events.

Higher gas prices will support electricity prices, providing temporary relief to coal plants with market exposure. However, higher natural gas prices and increased volatility are expected to be transitory in nature, easing when heating demand falls away.

Strong demand. Natural gas demand in the U.S. has been much stronger than historical norms on a temperature-normalized basis. Incremental demand per degree increased by an average of 5 billion cubic feet per day (Bcf/d) compared to seasonal norms during the

fourth quarter. This reflects inelastic changes in demand from the addition of more gas-fired generation capacity; new petrochemical plants and other facilities in the industrial sector; feed-gas deliveries for LNG export; and exports to Mexico. In total, U.S. natural gas demand grew by 9 Bcf/d YOY.

Demand has outpaced breakneck production growth in the Lower 48 that is averaging 81.4 Bcf/d – an astounding 8 Bcf/d, or 11 percent, higher YOY. This is the strongest YOY production growth seen in the last eight years.

Low inventories. Despite record production growth, surging demand kept injections low leading up to heating season. Gas inventories this year peaked at 3,247 billion cubic feet (Bcf) in the week ending November 9, 2018. This is almost 500 Bcf below last year and nearly 600 Bcf below the five-year average, making it the lowest level seen for early November in at least eight years. Unseasonably cold weather in November led to the strongest withdrawal on record for the first half of the month.

Volatile pricing. Low inventories, surging demand, and cold weather reintroduced volatility to U.S. natural gas prices. In mid-November, the contract for prompt-month settle reached $4.84, the highest November settlement price since 2009.

The futures market remains spooked with prices for settlement in March 2019, hovering around $4.40. Analysts expect Henry Hub gas prices could reach $10 per million British thermal units (MMBtu) during peak demand events this winter.

Coal plants will get a boost from higher natural gas prices, as indicated by higher implied heat rates. Implied heat rates are the efficiency rates at which the market cost of power equals the cost of burning fuel to generate power. Implied heat rates were 0.6 percent lower YOY in November for natural gas, but up 20 percent to as much as 43 percent over the same period for coal.

This support is likely transient in nature. Production continues to grow at record levels. New pipeline capacity out of the Northeast should provide ample supply for the market when heating demand falls off.

Between March and April of 2019, the futures curve points to a 30 percent decline in the settlement price to below $3/MMBtu. However, given strong growth in inelastic demand, the market will be watching closely for any weakness in production. Evidence of slowing production will quickly translate to natural gas prices above $3.50/MMBtu through 2019.

Rural Water Systems

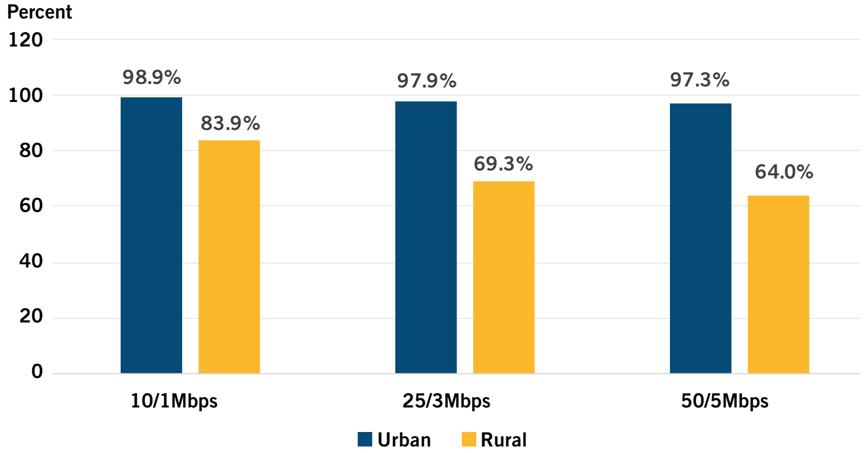
The need to replace outdated water and wastewater infrastructure, combined with drought pressure in the West, has pushed water rates higher across the country.

Combined water and wastewater bills in 2018 increased YOY by 3.6 percent on average. Water utilities are very sensitive to increasing water rates. To temper this, water utilities are exploring new rate tariffs and relying on enhanced smart meter technology to meet growing capital expense requirements, without placing significant financial pressure on low-income households.

New tariffs.

- **Social tariffs** such as the Tiered Assistance Program, or TAP, offer customers a consistent monthly water bill based on their income. The program is aimed at customers with an income below 150 percent of the federal poverty level. Standard monthly bills should allow customers to better budget their finances, which will lead to a decrease in delinquencies.

EXHIBIT 14: Urban vs. Rural Broadband Access*



Source: FCC
*As of 2016 (latest year available)

- **Drought tariffs** are also gaining traction. Cape Town, South Africa, was on the brink of running out of water earlier this year. The city implemented a drought tariff that permitted a household to consume roughly 50 gallons per day (the average U.S. household consumes 200 gallons per day). If a household exceeded this threshold, the water rate would skyrocket by 390 percent. This form of demand management enabled the city to come through the most recent drought without running out of water or spending massively on short-term resources. Similar tariffs will likely be duplicated in other drought-prone areas in the U.S., such as California and Texas.

Smart meters. Water utilities are also increasingly interested in using smart water meters to save water and reduce costs.

An estimated 12 percent of all indoor water consumption is lost to leaks in the U.S. At any given time, an estimated 10 percent of homes have a leak of 90 gallons or more per day.

A recent study of 85,000 residential customers that were upgraded to smart water meters indicates the huge potential these meters have for reducing leaks. Participants of the study were given access to an online portal where they could view their consumption information, and set alerts for when a leak was detected. In the first three months of portal access the following was achieved:

- 50 percent reduction in the number of households having a leak.
- New leaks were 17 percent shorter in duration compared to similar households without access.

Water utilities are responding to the need for improved infrastructure with greater capital expense spending. This has placed upward pressure on water and sewer rates, which continue to increase faster than inflation. However, innovative tariffs and proliferation of smart water meters are helping water utilities meet their capital expense needs without placing even greater pressure on low-income households.

Telecommunications

Under Chairman Ajit Pai, the Federal Communications Commission (FCC) has been quite vocal about wanting to expand rural broadband and address the digital divide. (*See Exhibit 14.*) He and other commissioners have spoken about these challenges frequently and have taken several public relations tours of rural markets to highlight the challenges and successes of rural broadband. This rhetoric has been joined by recent policy actions with far-reaching implications for rural broadband, including addressing some Universal Service Fund (USF) shortfalls, bringing regulatory relief for business data services, and expanding satellite broadband options.

A-CAM expansion. In December, the FCC voted to make some significant changes to the Universal Service Fund (USF) program. These changes:

- Address shortfalls in the high-cost fund of the USF.
- Expand the Alternative Connect America Cost Model (A-CAM) option.
- Attempt to broaden the reach of the FCC's current definition of 25/3 Mbps broadband to more parts of rural America.

For some time, the budget for the high-cost fund for both traditional rate-of-return and A-CAM programs has been short – by more than $200 million annually by some estimates.

Smaller rate-of-return carriers had to select the A-CAM program, which offered funding support based on a cost model, or remain in the traditional rate-of-return program. The A-CAM program ran into trouble from the very start as more carriers opted for the cost model program than the FCC anticipated or budgeted for.

The FCC has been trying to resolve these shortfalls for some time, and now aims to do a major fix. That fix includes expanding the A-CAM program in an effort to entice more carriers to opt-in. That enticement includes promising a fully funded model up to the $200 per-location cap. How the program will gain this full funding has not yet been explained by the commission.

These new support mechanisms also aim to expand 25/3 Mbps availability. Targets call for carriers to build 25/3 Mbps service to at least 50 percent, 65 percent or 85 percent of fully funded locations, depending on the density of the population in the carrier's service territory. These targets have been raised from previous 10/1 Mbps targets in many cases.

A proposed FCC budget of $1.42 billion annually would apply to the remaining carriers that choose not to opt in to the expanded A-CAM program. The budget could be adjusted downward depending on how many carriers accept the new A-CAM offer.

Business data pricing regulation. The FCC also recently voted to relax business data price regulation for certain rural carriers.

Rural carriers that opted in for A-CAM now have the option of transitioning to what the FCC calls "light-touch incentive regulation" for their business data services. The services in question for this new light-touch approach include lower-speed TDM data services that operate at speeds of 45 Mbps or less.

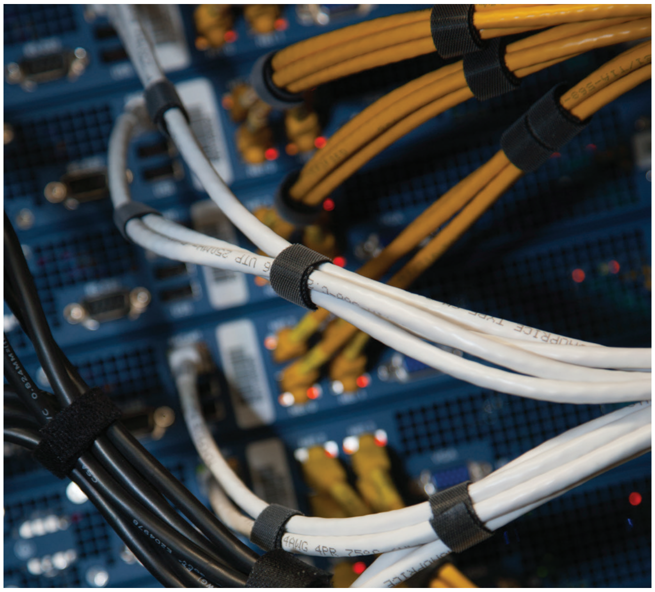
If a carrier has competition in any given market for those lower-speed TDM services, those services will be exempt from pricing regulation. The new FCC rules also call for participating carriers' packet-based business data services to be automatically exempt from "ex ante" price regulation.

These new rules also apply to certain companies affiliated with price cap carriers. Price cap carriers have enjoyed regulatory relief on their business data pricing for some time now. These changes reduce – sometimes eliminate – expensive cost study filings. At the same time, they give participating carriers the ability to offer volume and term discounts and individualized contract offerings for lower-speed data services.

Expanding satellite broadband options. Satellite-delivered broadband here in the U.S. is set to expand.

Existing satellite broadband provider ViaSat recently won more than $122 million from the CAF-II auction program. But ViaSat and its main competitor, Hughes, are set to see new satellite broadband players emerge, particularly from non-geostationary orbit (NGSO) satellites.

The FCC recently authorized three non-U.S. companies to offer U.S. NGSO satellite services. The commission also authorized U.S.-based SpaceX to deploy and operate a NGSO satellite constellation offering



broadband service around the world. In fact, the FCC has already approved a total of 13 market access requests and nine satellite applications involving NGSO satellites.

The three non-U.S. companies that were approved include Canada-based Kepler Communications and Telesat Canada, and European-based LeoSat. Telesat and LeoSat plan to offer satellite broadband services. Kepler is pursuing an internet of things (IoT) connectivity model.

U.S.-based SpaceX has gained approval to operate 7,000 satellites using V-band frequencies. The company has announced plans for Starlink, which will use those NGSO satellites to deliver satellite broadband to unserved and underserved markets across the globe.

NGSO satellites improve on some of the challenges of high-altitude geostationary satellites, including poor latency, due to their operation in lower earth orbits (LEOs). Geostationary satellites are 22,500 miles above Earth, while NGSO satellites can be as close as 211 miles above Earth. The tradeoff is many more satellites are needed for coverage than with higher-altitude satellites.

Noteworthy wireless developments. There are important ongoing wireless developments with implications for rural broadband. The FCC conducted its first 5G wireless spectrum auction in 4Q18 and established rules for a future CBRS spectrum auction.

5G auctions. Forty bidders qualified to participate in auction 101 of 28 GHz millimeter wave spectrum. Two licenses of 425 MHz each will be auctioned for each of the 1,500 counties covered by this auction. The spectrum can be used for both fixed and mobile services, providing very high bandwidth at short ranges.

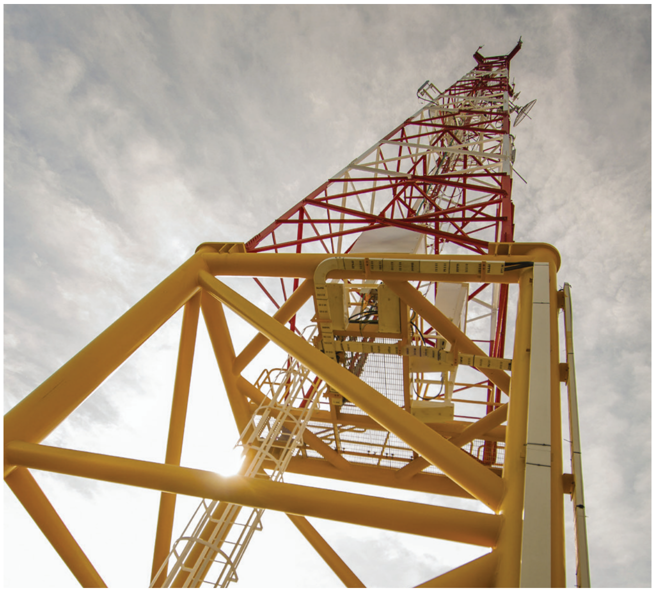
Of the 40 qualified bidders, eight qualified for rural service provider bidder credits. Other notable bidders with rural interests include Frontier, U.S. Cellular, and Windstream. AT&T and T-Mobile are the only two of the big four national wireless carriers qualified to participate in the auction.

According to a report written by Telecom Advisory Services for the Competitive Carriers Association, the 28 GHz auction will cover 61.7 percent of the land mass and 23.7 percent of the U.S. population. Several carriers, including Verizon, already have considerable 28 GHz spectrum holdings.

The auction was still taking place at the time of this report's writing but had raised $637 million through 46 rounds so far. Auction 102 for 24 GHz spectrum, also key to 5G service, will follow soon after auction 101 is completed. Thirty-four bidders have qualified to participate in auction 102. Notable qualified bidders for auction 102 include Verizon, cable MSO Cox, and competitive wireless provider Starry.

CBRS auction. Citizens Broadband Radio Service (CBRS) operates in the 3.5 GHz band and is attractive for both fixed and mobile broadband.

CBRS spectrum is coveted by both large national carriers, who can exploit the spectrum for 5G, and small rural providers, including wireless internet service providers, that can exploit it for fixed wireless. These



competing interests for the spectrum have led to some controversy regarding the upcoming auction rules and who those rules would favor – large national incumbents or small scrappy rural fixed wireless providers.

Much of that controversy centered around the geographic size of the license areas, with the resulting rules opting for county size licenses. This is generally considered a win for larger carriers. Smaller fixed wireless providers were hoping for census tract-sized license areas. The rules adopted by the FCC will extend license periods for CBRS spectrum to 10 years and make them renewable.

The FCC characterized the rules as "middle ground." Not everyone, including the Wireless Internet Service Providers Association, agrees with that assessment, however. The inclusion of rural and tribal bidding credits is one nod to this middle ground, according to FCC Commissioner Michael O'Rielly. The Rural Wireless Association, NTCA – The Rural Broadband Association, and the Competitive Carriers Association endorsed the FCC's CBRS auction rules.

A significant portion of CBRS spectrum, 80 MHz, will be available for unlicensed use. CBRS rules have provided a unique sharing arrangement built on a three-tiered framework of users consisting of incumbents, priority access licenses (PALs), and general authorized access (GAA) users. That framework remains largely in place, with these changes:

- PALs are subject to the new larger license areas.
- GAA users will use a portion of the CBRS spectrum on an unlicensed basis. The limitation: GAAs won't be able to use spectrum that is in use by incumbent military users or priority access licensees.

5G usage cases. All four national carriers and some smaller regional carriers have been talking 5G at a furious pace. Initial 5G deployments are set to begin from both Verizon and AT&T in late 2018. More deployments will follow in the next couple of years, with 2020 seen as the first year that 5G will begin to truly scale nationally.

Investments by all wireless carriers to bring 5G to market is measured in billions of dollars. Larger carriers are beginning to justify that investment through the identification of use cases and applications. Some examples of these use cases:

- **Virtual Reality** – Virtual Reality (VR) applications are often touted as being enabled with 5G. Verizon has offered examples of VR including the "5G First Man" experience that lets people walk in the shoes of Neil Armstrong as he experiences landing on and taking off from the moon. This experience involves sitting in a Positron (full-motion) chair and wearing a VR headset, allowing people to virtually see, hear, and feel what it was like to ride in the lunar capsule.
- **4K TV Demo** – 5G is arriving just as the next generation of HDTV, called 4K TV, begins to emerge. AT&T and FOX Sports recently teamed up to demonstrate how the two can work together. 4K HDR images from two FOX Sports cameras were streamed over a 5G network through a FOX Sports production truck, making the streams available to DirecTV viewers. The demo highlights how real-time streaming over 5G could enhance viewers' experience of sporting and other live events.

- **Fixed Wireless** – Using millimeter wave spectrum, Verizon is building 5G fixed wireless networks with plans to disrupt the wired broadband market. The service was launched on October 1, 2018, in Sacramento and Los Angeles, California; Houston, Texas; and Indianapolis, Indiana. The cost is $50 per month for existing mobile subscribers, or $70 per month as a standalone service. With speeds comparable to a wired broadband service, Verizon sees fixed wireless as an emerging business line for the company.
- **Industrial IoT** – Wireless carriers are touting the role 5G can play in the enterprise and with industrial IoT applications as well. Samsung and AT&T are collaborating at a Samsung semiconductor plant in Austin, Texas, where 5G is enabling 4K video sensors that improve plant security and detection response. Additional plant sensors monitor environmental and equipment conditions, such as vibration, temperature, and speed.

This quarterly update is prepared by the Knowledge Exchange Division and covers the key industries served by CoBank, including the agricultural markets and the rural infrastructure industries. Analysts at Plus One Strategic Communications LLC prepared the overview of the communications industry.

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Economist, Grain and Farm Supply

CoBank's Knowledge Exchange Division welcomes readers' comments and suggestions. Please send them to KEDRESEARCH@cobank.com.

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