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Maria Bowman, Maroua Afi, Aubree Beenken, Amy Boline, Mary Drewnoski, Fernanda Souza Krupek, Jay Parsons, Daren Redfearn, Steven Wallander, and Christine Whitt

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Abstract

Cover crops can provide environmental benefits, and their use is increasing across the United States. Cover crops can also be costly to implement. The literature suggests that for livestock operations, grazing or harvesting cover crops for forage can be profitable due to the forage benefit. However, a new analysis of Federal data shows that around 14 percent of cattle operations with cropland grew cover crops in 2017. Certain types of cattle operations are more likely to report cover crop use. Dairy and feedlot operations are more than twice as likely to use cover crops as cattle operations overall (33 percent of dairy and 27 percent of feedlot operations), and many operations with cover crops report grazing them or harvesting them for forage. In 2021, 72 percent of dairy operations and 89 percent of cow-calf operations with cover crops reported harvesting or grazing at least some cover crop acreage, which suggests the forage value of cover crops may be a driver of adoption on those operations. Finally, this report discusses the potential for integrating cover crops and livestock systems in the United States (as well as barriers) and presents several research opportunities that could address knowledge gaps.

Keywords: cover crops, grazing, livestock, forage, cattle, cow-calf operation, dairy, soil health practices, conservation practices

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A report summary from the Economic Research Service *May 2024*

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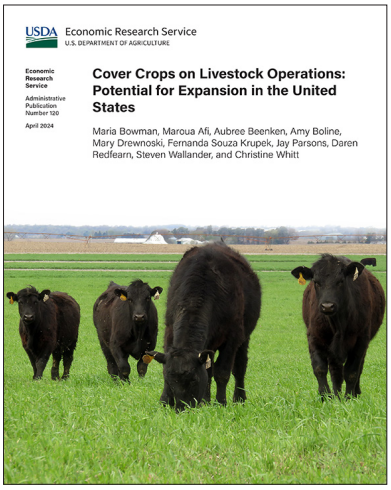
What Is the Issue?



Cover crops provide seasonal, living cover during a period when a crop might not otherwise be grown (e.g., late fall, winter, and early spring). While cover crops can provide multiple environmental and economic benefits both on and off the farm, the net benefits of cover crops vary by region, crop/livestock system, and operation. This report looks at how incorporating cover crops into an integrated crop-livestock system with cattle, such as by grazing or harvesting the cover crops for forage, might improve the profitability of cover cropping and livestock production. We summarize the literature on the profitability of using cover crops for forage, present new findings from census and survey data on the prevalence of cover crop use and grazing/harvesting on cattle operations, and examine the potential for increased adoption.

What Did the Study Find?

A literature review of the economic and agronomic potential for integrating cover crops into cattle operations found that:

- Most studies find that integrated livestock cover-crop systems tend to be more profitable than livestock systems without cover crops because the forage value of cover crops is greater than the costs of cover cropping.
- The profitability of cover crops in an integrated livestock system primarily varies with the choice of cover crop species and management practices, the amount of cover crop forage being consumed by livestock, and the agronomic effect of the cover crop on the cash crop.
- The profitability of cover crops in an integrated livestock system also varies with the fixed costs of the grazing/harvesting system, the size of the farming operation, producer experience, and regional variability in production systems, soils, and climate. These factors can also be barriers to the adoption of cover crops in livestock operations.

A statistical analysis of data from the USDA's 2017 Census of Agriculture revealed that cover crop adoption rates vary by region and livestock operation type.

- Despite the literature review finding that integrated livestock-cover crop systems tend to be profitable, overall adoption of cover crops by cattle operations with cropland is relatively low and similar to all farms with harvested cropland (14 percent versus 12 percent in 2017). This may reflect barriers to adoption or a lack of knowledge or technical expertise about how to implement such systems.
- Dairy and feedlot operations with cropland are more than twice as likely to grow cover crops as operations with cattle and cropland overall (33 percent of dairy operations and 27 percent of feedlot operations in 2017 versus 14 percent of cattle operations with cropland overall).
- The share of feedlot operations reporting cover cropping grew from 21 percent to 27 percent between 2012 and 2017.

Data from the Agricultural Resource Management Survey provide additional insights into how cover crops are managed.

- Grazing and harvesting cover crops for forage is common in cattle operations with cover crops. In 2021, 72 percent of dairy operations and 89 percent of cow-calf operations with cover crops reported harvesting or grazing at least some of their cover crop acreage.
- Dairy farms in the Northern Crescent region (comprised of Northeast and Great Lake States) are more likely to report growing cover crops that are not harvested for forage or other on-farm use. This could be related to climate, or regional policies, regulations, or programs that incentivize growing cover crops for water quality benefits.
- Grazing or harvesting for forage to terminate (kill) the cover crop is relatively rare. These two termination practices accounted for 13 percent of cover crop acreage on corn, soybean, sorghum, cotton, and barley fields.

There is potential to expand the use of cover crops in livestock systems in the United States, but there are also barriers.

- Regions such as the Eastern Uplands (which is characterized by small farms that are mostly part-time cattle, tobacco, and poultry farms and includes all of WV and parts of KY, TN, VA, NC, GA, AL, OK, MO, and AK) and central/eastern Texas and Louisiana have potential to expand cover cropping in livestock systems.
- In other regions, the feasibility to expand such systems is limited (such as much of the western United States) due to water and cropland availability.
- On dairy and cow-calf operations, on average, less than half of cropland is being cover cropped, and harvested cover crop acreage accounts for 26 percent and 18 percent of total cropland acreage on cow-calf and dairy operations with cover crops, respectively. This may indicate the potential to expand grazed or harvested cover crops on operations that are already cover cropping if a portion of total cropland acreage is not being cover cropped and/or if acreage that is already cover cropped is not being used for forage.

How Was the Study Conducted?

The authors conducted a literature review to examine the profitability of integrating cover crop and livestock systems, the forage benefit and livestock performance on cover crops, and the regional factors affecting the adoption of cover crop and livestock systems. The authors used operation-level and county-level data from the 2012 and 2017 Census of Agriculture to estimate cover crop adoption rates on cattle operations with cropland (including dairies, cow-calf operations, stocking/backgrounding operations, and feedlots) and identify regions with the potential to adopt integrated cover crop and livestock systems. The authors used data from the Agricultural Resource Management Survey (ARMS) to estimate the prevalence of grazed, harvested, and unharvested cover crops on dairy and cow-calf operations, as well as termination practices for cover crops. ARMS is a national survey of farming operations and production practices conducted by USDA's National Agricultural Statistics Service (NASS) and Economic Research Service (ERS). Operation-level data on cover crop acreage are based on the ARMS Cost and Returns Report (Phase 3) from the 2018–2021 survey years, and field-level data on termination practices come from ARMS Production Practice and Cost (Phase 2) field-level data.

Cover Crops on Livestock Operations: Potential for Expansion in the United States

Background and Literature Review

Cover crops were grown on 15.4 million acres or approximately 5 percent of cropland in 2017. Between USDA's 2012 and 2017 agricultural censuses, cover crop use increased by 50 percent across the United States, with the greatest increases occurring in the eastern United States. Federal programs such as the USDA Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP)—as well as many State programs—provide financial assistance to encourage the use of cover crops for their soil health and environmental benefits (Wallander et al., 2021). Cover crops can also be used as forage for livestock (either through grazing or harvesting for on-farm use), and these uses are compatible with current USDA cover crop termination guidelines (although the uses may not always have been in the past).[1] If cover crops provide a valuable source of forage for livestock operations, this on-farm benefit could increase cover crop adoption.[2]

Although cover crops are, by definition, grown on cropland, most cattle operations in the United States have at least some cropland that (in theory) could be cover cropped. For the cattle operations considered in this report (those that meet certain criteria to be considered a dairy, cow-calf, stocking/backgrounding operation, or feedlot; see note in table 1), more than three-fourths of the operations in each category have cropland (table 1). These operations may be growing annual crops for commodity markets or for forage (such as corn silage), growing perennial crops for hay or forage, and/or retaining cropland for land application of manure (such as on feedlots or dairies that face restrictions on land application of manure). Many cattle operations meet feed requirements through a combination of purchased and homegrown feed, and for these operations, cover crops can provide another potential source of forage grown on the operation. The bulk of this report focuses on the opportunity for farming operations with both livestock and cropland to grow cover crops on cropland that could be grazed or harvested for forage. In practice, this practice may look like the following examples:

- Cow-calf operations: May graze cover crops during the fall to reduce stored forage use or in the spring to extend the grazing season or allow a longer rest period for pasture.
- Dairy operations: May grow a cover crop during the fall following corn silage that can also be harvested for silage in the spring, such as winter wheat, cereal rye, or winter triticale.
- Stocking/backgrounding operations: May graze winter-hardy cover crops such as wheat during the fall and winter, or graze in the spring prior to termination.
- Feedlot operations: May plant cover crops on corn silage ground and graze recently purchased calves in the fall before transitioning them to feed or harvest the winter-hardy cover crops in the spring as silage to add as roughage to rations.

[1] For more information about the use of cover crops in the context of USDA programs and policies, see the USDA-NRCS Cover Crop Termination Guidelines (USDA, Natural Resources Conservation Service, 2019b) and the USDA-RMA Cover Crops Topic Page (USDA, Risk Management Agency, 2022).

[2] See, for example, the online NRCS Cover Crop Economics Tool that includes grazing as a potential benefit associated with growing cover crops.

Table 1
Estimated proportion of U.S. cattle operations that have cropland, and average amount of cropland in 2017

Type of operation	Proportion of farms with cropland (percent)	Average amount of cropland for operations with cropland (acres)
Cow-calf	76	402
Dairy	95	415
Stocking/backgrounding	75	569
Feedlot	93	729
All categories	78	418

Note: Dairy operations include all operations with at least 10 milk cows that do not meet the criteria for a cow-calf operation. Cow-calf operations include all operations with at least 20 beef cows in the survey year that do not meet the criteria for a dairy operation. Stocking/background operations do not meet the criteria for dairies or cow-calf operations, had no cattle on feed at the end of the year, and sold more than 50 head of cattle weighing more than 500 pounds. Feedlot operations do not meet the criteria for any other operation types and had more than 50 cattle on feed at the end of the year.

Source: USDA, Economic Research Service using data from the USDA, National Agricultural Statistics Service 2017 Census of Agriculture.

The types of cover crops that are grown and how they are managed can vary widely with the cropping/livestock system, region, and purpose/intended use of the cover crop.[3] These choices, in turn, affect the costs and benefits of the cover crop to the farmer (i.e., the profitability of the cover crop) and to society (e.g., water quality or greenhouse gas emissions reductions). For farmers growing a cover crop, management decisions include what cover crop(s) to plant and how and when to plant and terminate (or kill) the crop(s). Like cash crop management, cover crop management is dynamic and is affected by factors outside the farmer's control, such as weather.[4]

For operations involving grazing or harvesting the cover crop for forage, management decisions can be even more complex. Operations may choose cover crop species or mixes that have the most forage biomass potential, or time cover crop planting, grazing, and/or harvesting to meet seasonal forage goals (e.g., fall and/or spring grazing). Operations may also adjust cash crop management practices to incorporate a cover crop—for example, the operations may choose a shorter season corn or soybean variety that allows more time for cover crop planting and establishment. Figure 1 shows three examples of cover crop management systems in the United States that are designed to produce fall forage, spring forage, or both fall and spring forage. These systems may be suitable in different regions and livestock production systems due to constraints on cover crop growth and overwintering, the cash crop rotation, and the length/timing of the cash crop growing season (among other factors).

Understanding the potential to expand the use of cover crops for forage on livestock operations and the associated economic costs and benefits is the focus of this report. However, integrating cover crops into livestock operations—and cover crop use in general—can provide a number of other benefits that vary with location, cover crop species and management, and other factors (Snapp et al., 2005; Schipanski et al., 2014; Blanco-Canqui et al., 2015; Florence & McGuire, 2020).[5] Due to these benefits, there is also emerging interest in

[3] Integrating cover crops and livestock systems is one form of integrating livestock into cropping systems; other forms include grazing of cash crop residue, dual purpose cash crops (e.g., winter wheat grown for both grazing and harvest), and rotations in pasture-based systems that include both forage and grain crops.

[4] In some regions and cropping systems, these decisions may also include whether to irrigate or fertilize a cover crop to improve establishment or cover crop biomass growth.

[5] Rotational or management-intensive grazing is also broadly considered to be a soil health practice with economic and environmental benefits, though rotational grazing is not directly tied to grazing of cover crops. For more information about the adoption of rotational grazing on cow-calf operations in the United States, see Whitt and Wallander (2022).

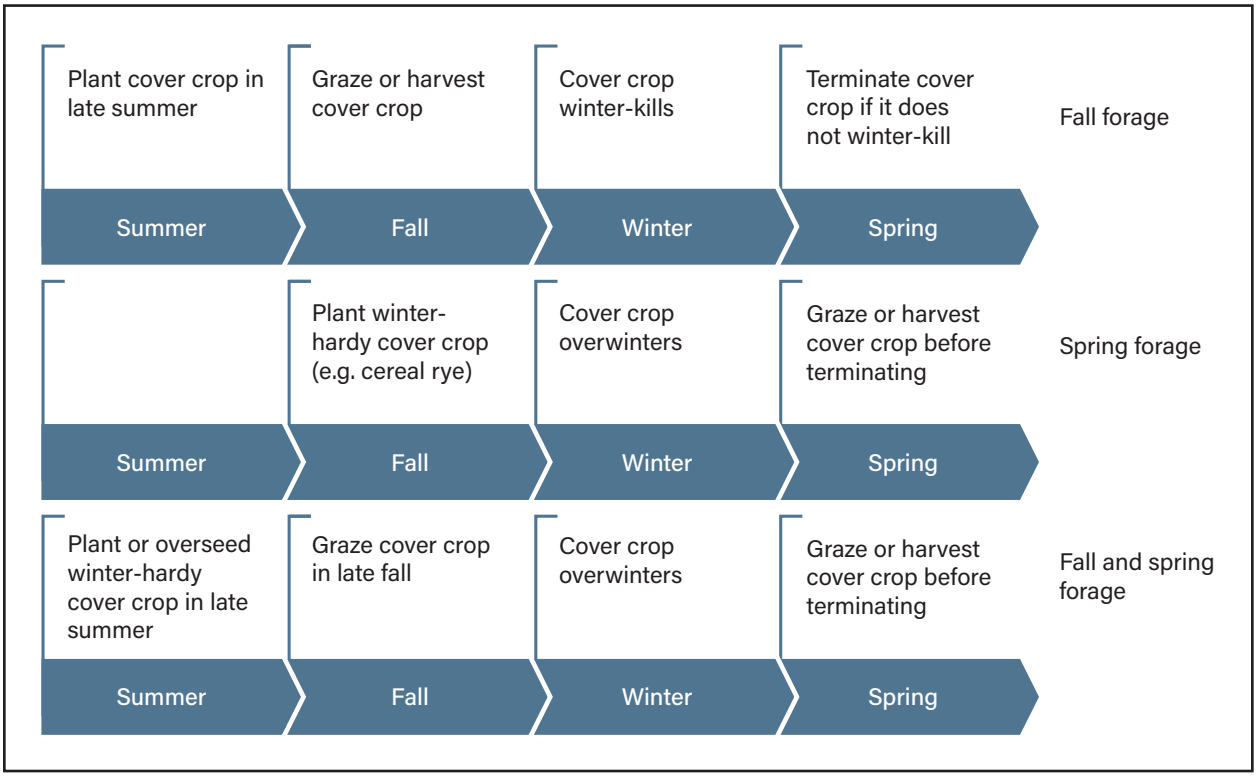
sustainable and cost-effective agricultural systems that integrate crops and livestock in the United States to adapt to increasingly severe and frequent extreme weather events such as droughts and floods (Walthall et al., 2012). Table A.1 in the appendix summarizes findings from several studies looking at the effect of cover crops on soil health and environmental outcomes in integrated cover crop and livestock systems (ICCLS) using cover crops. In general, these types of benefits may be more difficult to attach a dollar value to but stem from providing cover for the soil, having a growing plant (above and below ground) when there might not otherwise be a plant growing, and generating above and below-ground biomass. These benefits can include the following:

- Improvements in water quality associated with a cover crop's ability to remove excess nitrogen in the soil, reduce soil erosion, and improve rainfall infiltration (Thapa et al., 2018; Basche & DeLonge, 2019).
- Soil carbon storage or sequestration (Poeplau & Don, 2015; McClelland et al., 2021).
- Improvements in soil structure and water holding capacity and reduced erosion, which can improve soil and crop resilience to extreme weather events of increasing frequency (Rorick & Kladivko, 2017; Basche et al., 2016).
- For legume cover crops, the nitrogen produced can reduce the need for synthetic fertilizer use (Ebelhar et al., 1984).
- Cover crops can reduce pest pressure by providing weed control benefits and contributing to the control of herbicide-resistant weed populations (Florence et al., 2019), as well as increasing beneficial insect populations and affecting insect pests (Schipanski et al., 2014; Snapp et al., 2005).

Although there is limited research on how grazing or harvesting cover crops affects many of these benefits, the research that does exist suggests that, if well-managed, grazing cover crops has little or no negative effect on soils (Anderson et al., 2022; Blanco-Canqui et al., 2020a; Faé et al., 2009; Franzluebbers & Stuedemann, 2008a; Franzluebbers & Stuedemann 2008b; Schomberg et al., 2014; Stuedemann, 2007), although grazing can cause increased evaporation from reduced residue cover (Franzluebbers & Stuedemann, 2007). Even though above-ground biomass is removed when cover crops are grazed or harvested for forage, the soil still benefits from having a growing cover crop during a portion of the year and retaining cover crop root biomass (as well as some portion of the above-ground biomass). However, grazing of cover crops in some regions, cropping systems, and climates can also contribute to soil compaction, especially when grazing on unfrozen, wet soil (Dhakal et al., 2022; Schomberg et al., 2021).

Figure 1

Examples of common timelines of cover crop management for forage production in livestock systems in the United States



Source: USDA, Economic Research Service drawing on common cover crop management practices in the literature.

Federal Programs That Support Cover Crop and Livestock Integration

USDA, NRCS Environmental Quality Incentives Program

Producers may use several Environmental Quality Incentives Program (EQIP) practices to support cover crop and livestock integration, including the Cover Crop practice (practice 340). EQIP payment rates vary by State. For example, in fiscal year 2021, the EQIP payment rate was $24.04/acre for a single-species cover crop in Nebraska and $65.69/acre for a multi-species cover crop in Pennsylvania (USDA, NRCS, 2021). The USDA's Natural Resources Conservation Service (NRCS) does not typically provide financial assistance for cover crops that are grown with the primary intended use of grazing or harvesting for forage.

To motivate planting annual forage crops (including cover crops grown for forage), NRCS introduced the 810-Annual Forages for Grazing Systems interim practice in the State of Indiana in 2020. This practice supports establishing "adapted and compatible species, varieties, or cultivars of annual forage species suitable for pasture or fodder" (NRCS, 2019). In the future, other States may choose to offer the practice.

USDA, NRCS Conservation Stewardship Program (CSP)

USDA's Conservation Stewardship Program funds several practices, enhancements, and bundles related to cover cropping, soil health, and livestock production.

USDA, RMA Pandemic Cover Crop Program (PCCP)

As part of the USDA Pandemic Assistance for Producers initiative, USDA's Risk Management Agency offered $5 per acre in crop insurance premium support for producers who insured their spring crops with most insurance policies and planted a qualifying cover crop during the 2021 crop year. The program continued in 2022.

USDA, RMA Annual Forage Pilot Program

This program provides single-peril insurance coverage (lack of precipitation) for annual forage that is planted with the intended use of feed for livestock. The program is available in North Dakota, South Dakota, Nebraska, Kansas, Colorado, Oklahoma, New Mexico, and Texas—and insures annual forage using the Rainfall Index in these States. This program can be used to insure the forage value of cover crops planted for grazing or forage harvest in between two cash crops.

For more information about Federal and State programs that provide financial incentives for cover crops, see Wallander et al. (2021). For more information about the use of cover crops in the context of USDA programs and policies, see the USDA-NRCS Cover Crop Termination Guidelines (USDA, Natural Resources Conservation Service, 2019b) and the USDA-RMA Cover Crops Topic Page (USDA, Risk Management Agency, 2022).

Overview of Economic Benefits of Integrated Cover Crop/Livestock Systems

In the United States, using cover crops for grazing or forage is widely cited as one way to improve the economic profitability of cover cropping (Plastina et al., 2018; Smith, 2020; Soil Health Institute, 2021). In addition, integrating cover crops and livestock can provide opportunities for income diversification or risk mitigation in the face of climate change and economic risk (Kumar et al., 2019).[6] Rising interest in integrated cover crop and livestock systems (ICCLS) and grazing cover crops to diversify the farming operation has increased the demand for research and information about how cover crop grazing and forage value affect profitability (Thiessen Martens & Entz, 2011; Russelle et al., 2007). Several factors affect the profitability of integrating cover crops and livestock. These factors operate primarily through their effect on how much biomass/forage the cover crop produces, as well as how much of that forage is consumed and the quality of the forage. Additional factors include the agronomic/economic effects of the cover crop on the following cash crop, fixed costs associated with transitioning to grazing/harvesting of cover crops, and other characteristics of the operation that impact the economics of adoption.[7]

The choice of cover crop species in the context of the cash crop system is an important variable driving biomass production and the costs of cover cropping. In the case of grazing of cover crops (table 2), the value of forage production on the operation is determined by a combination of cover crop species selection, as well as management and optimizing consumption through stocking rates and timing of grazing.[8] This choice intersects with cash crop decision making, as the prior cash crop can limit the planting window for cover crops and affect cover crop establishment—and the cover crop can have agronomic and economic effects on the following cash crop.[9] In the case of cover crop grazing, the manure distributed on the field by grazing cattle is an input to the production for the subsequent cash crop, with potential positive effects on fertilizer costs over time (Rai et al., 2021). Finally, fixed costs and economies of scale on grazing operations can be important drivers of the profitability of grazing cover crops. As noted in table 2, farms that specialize in crop production and are transitioning to integrated crop and livestock systems often have upfront costs associated with starting a livestock enterprise. However, even for livestock operations, transitioning to grazing cover

[6] The International Panel on Climate Change (IPCC) highlights integrated crop-livestock systems (ICLS) as both a resource-efficient and cost-effective strategy for agricultural adaptation and sustainable food production in the face of climate change (IPCC, 2018).

[7] Note that the ability to estimate the economic value of on-farm forage production is somewhat limited by the fact that there are not typically sales that are observed, and the value of alternative purchased feed is not always a good proxy.

[8] See Whitt and Wallander (2022) for more information about the adoption of rotational grazing on cow-calf operations in the United States.

[9] These agronomic and economic effects are affected by several variables, including cover crop species choice, planting date, seeding rate, and termination dates and methods, among other factors.

crops often requires an upfront investment in fencing and watering infrastructure.[10] Labor costs may also be higher, as grazing of cover crops can be relatively management intensive (Sulc & Franzluebbers, 2014; Sulc & Tracy, 2007). For example, the producer may need to watch field conditions closely and move animals frequently or across long distances (depending on the spatial configuration of the operation) to ensure cattle are not adversely affecting field conditions and have adequate forage biomass available. The per-acre cost of this investment may be lower for larger operations due to economies of scale (Rai et al., 2021). Note that in this report, the authors focus on the economics of cover cropping in livestock systems with cattle but acknowledge that producers raising other ruminants (such as sheep and goats) also use cover crops for forage.

Table 2
Key factors contributing to the feasibility and/or profitability of grazing cover crops

Factor	Results	Source
Challenges in water-limited agroecosystems	Cover crop reducing soil available water for succeeding cash crop.	Holman et al. (2018), Reese et al. (2014), Rai et al. (2021)
	Cover crop biomass variability is highly related to annual precipitation.	Kelly et al. (2021)
	Trade-off between forage production and water use in dryland systems.	Kelly et al. (2021)
Short-term economic or soil health benefits	Negative profitability in the short-term is a major barrier to wide adoption of cover crops; soil properties like soil organic carbon may be slow to change.	Plastina et al. (2020), Roesch-McNally et al. (2018), Kelly et al. (2021), Wood & Bowman (2021)
Producer experience and/or time to obtain and manage grazing livestock	Livestock increasing labor and time required by 50 percent and 30 percent, respectively, in North Dakota. Lack of management skills and knowledge of ICCLS can delay adoption.	Gardner & Faulkner (1991), Dunlap et al. (2000), Krall & Schuman (1996)
Cover crop biomass consumption	Optimizing site-specific stocking rate or increasing grazing duration can maximize cover crop biomass consumption and hay saved.	Rai et al. (2021)
Cash crop yield following cover crop	Including N-fixing cover crop species in the mixture and terminating early in the summer may increase cash crop yields.	Blanco-Canqui et al. (2012), Nielsen & Vigil (2005), Schlegel & Havlin (1997)
Cover crop species selection	Optimizing biomass production and reduce production costs—single species (e.g., cereal rye) or simple mixes are adequate since mixes are not any more productive than single species.	Hendrickson et al. (2021), Ruis et al. (2019)
Value of manure during grazing period	Reduction of nutrient inputs for cash crop if fertilizer rates are adjusted.	Rai et al. (2021)
Size of farming operation	Returns to scale on larger operations; cost of fence and water vary from low ($3/acre) on a 5,120-acre ranch to high ($70/acre) on a 101-acre pasture.	Rai et al. (2021)
Fixed costs of grazing cover crop in ICCLS are associated with infrastructure (e.g., fence or water) or land/livestock ownership	Challenges may be addressed by financial support in the form of loans or government programs.	Krall & Schuman (1996), Prokopy et al. (2015)

ICCLS = integrated cover crop and livestock systems; N = Nitrogen.

Source: USDA, Economic Research Service summarizing findings from sources listed in table.

[10] These types of upfront, fixed costs can be lessened or shared through creative lease arrangements, contract grazing, or tools such as the South Dakota or Midwest Grazing Exchanges (available online) that connect operations with available forage with operations with livestock.

The literature presented in table 3 suggests integrating cover crops into livestock systems generally improves profitability.[11] For example, using scenario analysis drawing on results from a field experiment conducted at South Dakota State University, Rai et al. (2021) found that longer grazing periods or an increased stocking density that lead to the consumption of 50 percent of the cover crop biomass are expected to generate net returns[12] in integrated crop and livestock systems ($213/acre) and exceed the net returns of crop production alone ($146/acre) or crop production with a non-grazed cover crop ($123/acre). At lower levels of cover crop biomass consumption (~20 percent), grazing cover crops did not significantly increase profitability.

Table 3
Summary of literature findings on effects of integrated cover crop and livestock systems with cover crop grazing on cash crop yield, profit, and costs

Outcome	State	Treatment	Effect of treatment on outcome	Sources
Cash crop yield				
Corn yield	SD	non-grazed cover versus ICCLS	↔	Rai et al. (2021), Tobin et al. (2020)
	SD, IL	non-grazed no cover versus ICCLS	↔,↑	Rai et al. (2021), Maughan et al. (2009)
Soybean yield	SD	non-grazed cover versus ICCLS	↔	Rai et al. (2021)
	SD	non-grazed no cover versus ICCLS	↔	Rai et al. (2021)
	NE	non-grazed no cover versus ICCLS	↑	Drewnoski et al. (2016)
Wheat yield	CO, KS, NE, ND	non-grazed no cover versus ICCLS	↓	Kelly et al. (2021)
	GA, CO, KS, NE	non-grazed cover crop versus ICCLS	↔	A. J. Franzluebbers & Stuedemann (2004), Kelly et al. (2021)
	SD	non-grazed no cover versus ICCLS	↑	Landblom et al. (2016)
Cotton and peanut yield	GA	non-grazed cover crop versus ICCLS	↔	Hill et al. (2004)
Sorghum yield	GA	non-grazed cover crop versus ICCLS	↔	A. J. Franzluebbers & Stuedemann (2004)

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[11] Grazing of winter wheat that is later harvested (dual purpose wheat) is another example of integrated crop livestock systems. Although this example would not meet most definitions of a cover crop, the literature provides some insight into the economics of integrated crop and livestock systems (Sulc & Franzluebbers, 2014).

[12] See Rai et al. (2021) for exact methods for calculating profit/net return.

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Outcome	State	Treatment	Effect of treatment on outcome	Sources
Economic analysis				
Profit	SD, GA, AL	non-grazed cover versus ICCLS	↑	Rai et al. (2021),* Hill et al. (2004), Siri-Prieto et al. (2005), Gamble et al. (2005), Franzluebbers & Stuedemann (2004)
	SD	non-grazed no cover versus ICCLS	↑	Rai et al. (2021),* Tobin et al. (2020)
	NE	grazed cover crop versus corn residue	↑	Cox-O'Neill et al. (2017)
		grazed cover crop versus drylot feeding	↑, ↔	
Costs	SD	non-grazed cover versus ICCLS	↔	Rai et al. (2021)
		non-grazed no cover versus ICCLS	↔	Rai et al. (2021)
		non-grazed no cover versus ICCLS	↔	Rai et al. (2021)
Other factors				
Weed control	MT	Monoculture versus ICCLS	↑	Miller et al. (2015)

* (50 percent biomass consumption)

"↑" increase, "↓" decrease, "↔" neutral effect

ICCLS = integrated cover crop and livestock system.

States: AL = Alabama, CO = Colorado, GA = Georgia, IL = Illinois, KS = Kansas, MT = Montana, NE = Nebraska, SD = South Dakota.

Source: USDA, Economic Research Service using sources cited in table.

Table 3 also suggests that increased profit from integrating cover crops into livestock operations is due to the direct benefits from forage production rather than through any effect on cash crop yields or reduced costs following the cover crop. The estimated effects of cover crop and livestock systems on cash crop yield in the studies considered in this report ranged from negative to neutral to positive (depending on the region and the study), but the effect on profitability was more consistently positive.

Grazing cover crops or harvesting them as small grain silage can reduce the amount of purchased feed and/or extend the grazing season and may improve profitability (Ketterings et al., 2015). The amount of hay or supplemental feed saved by grazing or harvesting cover crops is a straightforward determination. However, ultimately, the profitability of grazing or harvesting cover crops also depends on forage production, animal performance on cover crop forage at different stages of production, when the cover crop is grazed (e.g. during the winter vs. during the growing season), length of time the cover crop is grazed (if grazed), and the input costs and feasibility of grazing or harvesting the cover crop (Bakker et al., 2021; Lundy et al., 2018). Table A.2 in the appendix summarizes seasonal forage production for different cover crop species in different U.S. States and suggests that the nutritive value of cover crop forage varies temporally and by species (Ruis et al., 2019; Blanco-Canqui et al., 2020b). In general, grass species tend to produce more biomass (Ruis et al., 2019).[13] This means that when deciding what cover crop species to plant, farmers looking to maximize the forage value of the cover crop typically consider cover crop growing conditions, the suitability of the cover crop species/variety or mix, and how this intersects with forage production goals.

[13] Wallander et al. (2021) found that the most used cover crops in the United States are grasses/small grains—such as cereal rye and winter wheat.

To our knowledge, there is no literature that directly compares the profitability of grazing cover crops to harvesting them for forage. However, harvesting cover crop forage is an alternative to grazing that is used in different systems across the United States. Unlike grazing, harvesting cover crops for forage does not require installing fencing or livestock watering infrastructure and may have lower labor requirements because they can be mechanically harvested. To the extent that cover crops can be mechanically harvested, more intensive land use of crop acreage may also change land use allocation on the rest of the farm or allow for an increase in herd size supported by on-farm forage production. Harvesting of cover crops may also have risk management benefits, as harvested forage can be stored or sold during times of high feed prices or feed shortages (as in times of drought). At the same time, harvesting cover crops for hay or silage does require labor, machinery, and storage infrastructure (which have costs) (Duncan et al., 2022). Dairy and beef producers in Ohio, Pennsylvania, New York, and other States have found chopping small cereal grains such as rye, wheat, oats, and triticale for silage can help extend their forage supply (Richer, 2013; Holden, 2020).[14] Mowing the cover crop for hay is another option; however, getting the forage dry enough during wet spring months can be a challenge (Ishler, 2018).[15]

The Economics of Integrating Livestock and Cover Crop Systems Vary Regionally

Many of the factors that affect the profitability of integrated cover crop and livestock systems vary regionally with differences in production systems, climate, soils, and other biophysical factors. Precipitation and temperature are primary drivers of cover crop biomass production and may limit the economic potential of cover crop use in livestock systems. As a result, research results from trials in the southeastern States (table A.2) show higher biomass production of cover crops compared to the upper Midwest and northern States. Variability in temperature and/or precipitation can influence the economics of cover cropping even within a single State. For example, approximately one-third of cover crop users in Nebraska reported that the primary reason they grew cover crops was for livestock forage, but cover crops are much less prevalent in the more arid, western regions of the State, where most of the grazing livestock are located (Jansen et al., 2019). In northern latitudes, temperatures and the length of the growing season can also limit the cover crop species suitable for planting and/or constrain the timing of cover crop planting, grazing, or harvesting. In those regions, operations may be more likely to use cover crop seeding methods that allow for planting or seeding of the cover crop before the harvest of the previous cash crop (such as interseeding, overseeding, or aerial seeding of the cover crop), although these methods may have tradeoffs in terms of consistency of forage production (Franco et al., 2021; Logsdon et al., 2021; USDA, Natural Resources Conservation Service, 2010). Regional considerations for cover crop and livestock systems and some literature specific to different regions of the United States are discussed in the next section.

Southeastern United States

In the Southeastern United States (e.g., Florida and the Southern Seaboard Farm Resource Region presented in figure 2), the warm and humid climate favors year-round crop production, which creates opportunities to integrate cover cropping and livestock through the incorporation of cover crops in common short-rotation cropping systems (Stuedemann, 2007). Cover crops have been used for winter grazing on cow-calf operations.[16] Winter grazing of cover crops (e.g., oats, rye, and ryegrass) by stocker cattle in Georgia and Alabama has been estimated from trials to increase farm income by $101−151/acre for owned cattle in Georgia (Hill et al., 2004) and $75−-81/acre for contract-grazed cattle in Alabama (Siri-Prieto et al., 2005; Gamble et al., 2005).

[14] A survey of 20 well-managed dairy operations that included small-grain silage as part of their cropping rotation found the cost of production to range from $33.90/ton with 8.2 as-fed ton/acres of silage produced to $61.60/ton with a yield of 5.5 as-fed tons/acres (Ishler, 2018).

[15] There may also be decreased cover crop termination costs depending upon the type of cover crop planted and the timing of grazing and/or harvesting the cover crop for forage.

[16] Other typical ways of integrating crop and livestock systems in the southeast include sod-based systems, such as those that incorporate bahiagrass (Paspalum notatum), which is grazed by cattle into peanut and cotton cash crop rotations or by adding a perennial grass into hay or forage rotations.

Northern Great Plains

In the Northern Great Plains, crop and livestock production contribute significantly to the economy, but intensive row crop production predominates (Kumar et al., 2019). Integrating crop and livestock systems in this region began with annual crop residue utilization (Schmer et al., 2017), and cover crop adoption has steadily grown because the adoption provides additional grazing opportunities. Depending on the window available for planting and the species selected, cover crops can provide early autumn, late spring, and/or early summer grazing (Kumar et al., 2019). Rai et al. (2021) suggested that such systems can be profitable in South Dakota if cover crop biomass utilization is high enough. Another study conducted in South Dakota integrated cattle during winter months to graze grass and legume mixtures of cover crops in a corn-soybean-rye rotation. Even though cash crop yields were not significantly improved, land use efficiency was enhanced due to mixed crop and livestock enterprises, resulting in profit increases of $17.23/acre and $43.61/acre with the implementation of grazed cover crops in the first and second year of the study, respectively (Tobin et al., 2020).

Northeastern United States

There is growing interest in using cover crops in corn silage rotations, particularly in dairy farms located in the Northeastern United States (Ketterings et al., 2015). In 2021, 20 percent of corn silage acres nationally were estimated to have planted a cover crop the previous fall, which is a higher rate of cover crop use than preceding any other crop in USDA's Agricultural Resource Management Survey. The use of cover crops following corn silage harvest can benefit both soil conditions and profitability on dairy operations by recovering and retaining residual nitrogen and providing soil cover following silage harvest, which leaves little residue on the soil surface (Doran & Smith, 1991; Meisinger et al., 1991; Staver & Brinsfield, 1998). In contrast to corn, sorghum, or other crops being grown for grain, crops grown for silage are typically harvested earlier and at a higher moisture content for optimal storage and/or fermentation. An earlier harvest date can mean a longer window to plant cover crops and get them established, which may ease logistical constraints and improve success with cover crop establishment after silage crops.

Another important driver of cover crop use in livestock operations in the Northeast is regulations that target manure application on cropland, for example, in the Chesapeake Bay watershed or Great Lakes region. Manure is the primary source of nutrients for corn production on dairy farms in the Northeastern United States (Ketterings et al., 2003; Cela et al., 2014; Farsad et al., 2011). In Pennsylvania, manure management regulations implemented in 2011 effectively require dairy farmers to use cover crops following corn silage if producers want to apply manure to cropland during the winter (Hively et al., 2015; Pennsylvania Department of Environmental Protection, 2011). By limiting the application of manure to fields with more than 25 percent groundcover (crop residue or cover crop), this change in State policy contributed to increases in cover cropping in Pennsylvania around the time the change was implemented (Hively et al., 2015).

Midwest

In the Midwest, when cover crops are planted after wheat harvest, corn silage harvest, or the destruction of the male rows in seed corn, there is a long enough growing window that the cover crop can produce 2,200 to 6,000 pounds/acre of dry matter of high-nutritive forage for fall grazing (Drewnoski et al., 2018; Faé et al., 2009). Oats and brassicas are common cover crop species choices in these situations due to the short growing window and their ability to produce sufficient biomass in time for fall grazing, along with their high digestibility (energy value), high crude protein, and that they maintain their nutritive quality into the winter (Drewnoski et al., 2018). The nutritive value of these cover crop forages is high enough to meet the relatively high nutrient needs of weaned growing calves or lactating fall-calving cows. Grazing growing calves on cover crops in the fall for 20 to 70 days has resulted in average daily gains of 1.08 to 2.36 pounds/day with calves grazing oats (Brinton et al., 2019), cereal rye (Lundy et al., 2018), and an oats/brassica mixture (Cox-O'Neill et al., 2017; Speer et al., 2021) as shown in table A.2. In the Midwest, the grazing of fall cover crop forage can also provide a rest and recovery period for perennial pasture before entering winter.

The Use of Cover Crops on Livestock Operations in the United States

In our review of the economic and agronomic potential for integrating cover crops into livestock operations, we found that such systems often improve profitability. However, the profitability of growing cover crops for grazing or forage is variable and related to many other geographic and economic factors. In this section, we included Federal census and survey data to see when and where livestock operations are cover cropping (and harvesting cover crops) in the United States. We also reported some limited information on the prevalence of grazing of cover crops. To our knowledge, this report is the first to attempt to quantify the prevalence of grazing and harvesting cover crops for forage or the rates of adoption of cover crops in livestock operations across the United States.

Federal data sources with information about the use of cover crops by livestock operations (and the profitability of using cover crops for grazing/forage) are relatively limited. To understand what types of farm operations are using cover crops for grazing and forage, in what regions these practices are most common, and the potential for future expansion, the authors explored several data sources in this report. Broadly, these sources include data from the 2012 and 2017 USDA, Census of Agriculture and the USDA, Agricultural Resource Management Survey (ARMS). In table 4, the authors provide information about each data source used, including where to find additional documentation of survey or reporting methods. In many cases, the authors break down adoption rates and other statistics by USDA, ERS Farm Resource Region (figure 2) and by operation type (table 5). The authors focused on operations with cattle due to the smaller number of operations with sheep and goats, which limits the potential for analysis with census and survey data.

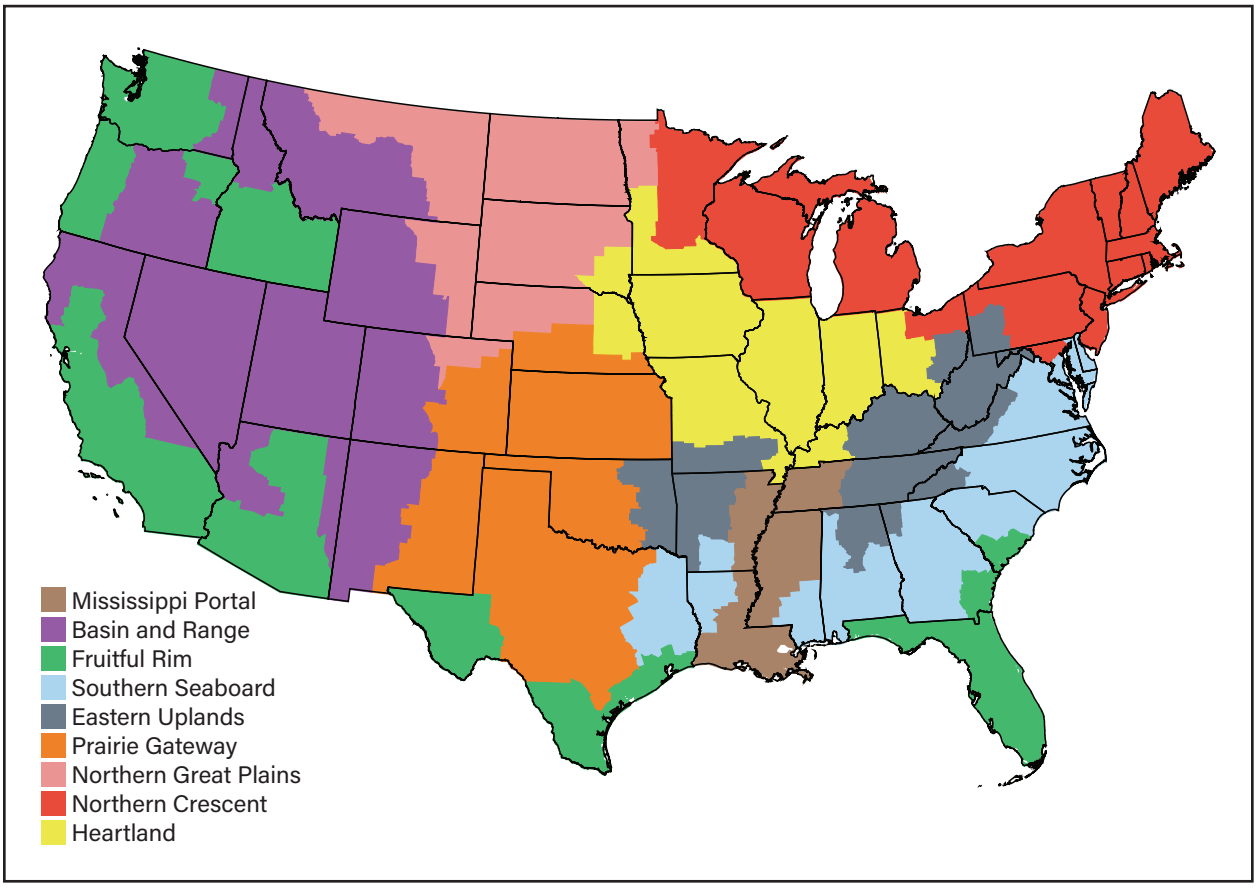
Table 4
Data sources used in this report, 2012–21

Data source	Years/crops used	Additional information
Agricultural Resource Management Survey Costs and Returns Report (Phase 3)	2021	Producers are asked how many acres of cover crops they had on their operations in three categories: harvested for forage, whether grazed or not grazed; grazed but not harvested for forage; and not grazed or harvested for forage (page 3, questions 17d, 17e, and 17f on the 2021 survey)
Agricultural Resource Management Survey Costs and Returns Report (Phase 3)	2018, 2019, and 2020	Producers are asked how many acres of cover crops they had on their operations that were not harvested, and how many acres of cover crops were harvested for forage or other on-farm use. (page 3, questions 15d and 15e on the 2020 Survey)
Agricultural Resource Management Survey Production Practice and Cost Report (Phase 2)	2018, 2019, and 2021	Producers report 4 years of crop history, including cover crops. For cover crops, they report the species or species category as well as the termination method. (page 7, question 19 in the 2018 Soybeans Survey)
USDA Agricultural Census	2012 and 2017	Producers are asked how many acres of cover crops they had on their operation (page 4, section 4, Land Use Practices on the 2017 Census)

Note: For more information about the Agricultural Resource Management Survey, please consult the "ARMS Farm Financial and Crop Production Practices" section of the USDA, ERS website. For more information about the USDA Agricultural Census, consider reviewing the 2017 Agricultural Census Report Form.

Source: USDA, Economic Research Service using the USDA Agricultural Censuses, USDA Agricultural Resource Management Survey (ARMS) Surveys, and associated documentation.

Figure 2
USDA, Economic Research Service Farm Resource Regions



Note: USDA, Economic Research Service (ERS) Farm Resource Regions depict geographic specialization in production of U.S. farm commodities. The regions identify where areas with similar types of farms intersect with similar physiographic, soil, and climatic traits.

USDA, ERS Farm Resource Regions exclude Alaska and Hawaii.

Source: USDA, Economic Research Service describing the regions from the USDA, Economic Research Service Agricultural Information Bulletin Number 760 (Heimlich, 2000).

Table 5
Types of livestock operations with cattle considered in this report

Type of livestock operation	Data sources considered	Criteria
Dairy	ARMS Phase 3 Agricultural Census	▪ Operation has at least 10 milk cows
Cow-calf	ARMS Phase 3 Agricultural Census	▪ Operation is not dairy ▪ Operation has at least 20 beef cows (see note)
Stocking/backgrounding	USDA Agricultural Census	▪ Operation is not dairy ▪ Operation is not cow-calf ▪ Operation had no cattle on feed at the end of the year ▪ Operation sold more than 50 head of cattle weighing more than 500 pounds
Feedlot	USDA Agricultural Census	▪ Operation is not dairy ▪ Operation is not cow-calf ▪ Operation had more than 50 cattle on feed at the end of the year

ARMS = Agricultural Resource Management Survey.

Note: Although feedlots and stocking/backgrounding operations in ARMS Phase 3 survey data were observed, there was not a large enough sample of these types of operations to be able to provide reliable, regional statistics for these operation types from the ARMS data—only in the USDA Agricultural Census data. Operations that meet the criteria for a livestock operation may also have cropping operations that are, in some cases, larger than the livestock portion of the operation. A beef cow refers to a bovine female of a beef cattle breed. Beef cows are bred to produce calves that ultimately enter the beef supply chain. Some operations that meet the above criteria for a feedlot may be stocking/backgrounding operations with cattle on feed during winter months.

Source: USDA, Economic Research Service.

Cover Crop Adoption on Cattle Operations in the USDA 2012 and 2017 Censuses of Agriculture

Despite the economic potential of integrating cover crops in livestock systems, the authors' analysis of national census and survey data shows that a minority of cattle operations with cropland have adopted cover crops.[17] This finding may reflect barriers to adoption or a lack of knowledge or technical expertise about how to implement such systems. Overall, cattle operations with cropland show similar rates of cover crop adoption to all farms with harvested cropland (14 percent versus 12 percent in 2017).[18] However, the authors also found that certain types of cattle operations (dairy operations and feedlot operations) are more likely to use cover crops on average than operations with harvested cropland overall. Analysis showed that 33 percent of dairy operations and 27 percent of feedlot operations reported cover cropping in 2017 (table 6). The higher rates of adoption on dairy and feedlot operations might be due to a higher marginal value of the forage produced by cover crops when animals are being fed in confined or semi-confined settings or because some dairy and feedlot operations are subject to restrictions on land application of manure or must follow a nutrient management plan (which might include cover crops). Corn silage is often commonly grown on dairies, and because corn silage leaves less residue after harvest, cover crops may be more frequently used to meet conservation or soil health goals.

[17] Farmers' self-reported cover crop usage in USDA surveys may not perfectly correspond to the USDA, Natural Resources Conservation Service cover crop practice standard or other definitions of cover crops.

[18] Some livestock operations may not have cropland or land that can be cover cropped; the authors reported cover crop adoption rates for all livestock operations with cattle and cropland. Even livestock operations with animals in confinement (e.g., dairies or feedlots) may have adjacent cropland due to having both crop and livestock operations or to satisfy requirements for land application of manure. For the purposes of this report, the authors classified operations by their type of production; for additional information about definitions for animal feeding operations (AFOs) and concentrated animal feeding operations (CAFOs), see USDA, Natural Resources Conservation Service (2022).

Certain regions were also more likely to show high adoption of cover crops in cattle operations or operations of certain types. For example, cover crop adoption in cow-calf operations was highest in the Northern Crescent and Heartland regions, and adoption in operations that specialized in stocking/backgrounding was relatively higher in the Northern Crescent, Heartland, Eastern Uplands, and Southern Seaboard regions. For more information about how and why adoption might vary regionally, see "The economics of integrating livestock and cover crop systems vary regionally" in the Background and Literature Review section.

Although the overall share of cow-calf, dairy, and stocking/backgrounding operations reporting cover cropping did not change substantially between the 2012 and 2017 Agricultural Censuses, the share of feedlot operations reporting cover cropping grew from 21 percent to 27 percent during this period. Growth in cover cropping on feedlots between 2012 and 2017 occurred primarily in the Heartland and the Southeast. Data suggest that cover cropping also expanded on cow-calf and stocking/backgrounding operations in the Heartland and in the Northern Great Plains, while some region/operation type combinations showed evidence of decreased adoption (table 6). A lack of growth in cover crop adoption on dairy operations may be related to higher rates of cover crop adoption overall and, therefore, less potential for growth in adoption.

Table 6
Estimated proportion of cattle operations with cropland adopting cover crops by USDA, Economic Research Service Farm Resource Region in the USDA, 2012 and 2017 Census of Agriculture

	Cow-calf (percent)		Dairy (percent)		Stocking/ backgrounding (percent)		Feedlot (percent)		Overall (percent)	
	2012	2017	2012	2017	2012	2017	2012	2017	2012	2017
Basin and Range	8	9	10	11	6	6	6	28	8	9
Eastern Uplands	9	8	36	37	16	15	21	49	11	10
Fruitful Rim	7	8	9	11	8	11	5	5	8	8
Heartland	14	18	36	34	16	19	16	25	17	20
Northern Crescent	20	18	37	36	34	31	37	34	32	30
Northern Great Plains	8	12	13	12	4	8	13	11	8	12
Prairie Gateway	6	8	13	14	8	12	9	14	7	8
Mississippi Portal	5	7	15	19	11	9	-	-	6	7
Southern Seaboard	9	9	37	41	25	14	-	-	11	11
Southeast*	-	-	-	-	-	-	43	50	-	-
All regions	10	11	34	33	16	17	21	27	14	14

Note: The Mississippi Portal and Southern Seaboard regions were combined into a Southeast region for feedlot operations due to the small number of feedlot operations in these regions. Dairy operations include all operations with at least 10 milk cows that do not meet the criteria for a cow-calf operation. Cow-calf operations include all operations with at least 20 beef cows in the survey year that do not meet the criteria for a dairy operation. Stocking/backgrounding operations do not meet the criteria for dairies or cow-calf operations, had no cattle on feed at the end of the year, and sold more than 50 head of cattle weighing more than 500 pounds. Feedlot operations do not meet the criteria for any other operation types and had more than 50 cattle on feed at the end of the year. Many small U.S. operations and hobby farms with livestock do not have a large enough livestock inventory to meet these criteria.

Source: USDA, Economic Research Service using data from the USDA, National Agricultural Statistics Service (NASS) 2012 and 2017 Census of Agriculture.

Several operation-level variables are likely correlated with cover crop adoption, and examining these variables was not the focus of this report. However, in table 7, the authors summarized how cover crop adoption on cattle operations with cropland varies by operation type and farm size in the 2017 Census of Agriculture. Although it has been documented that farm size is positively associated with cover crop adoption and the adoption of other conservation practices (Lee & McCann, 2019; Prokopy et al., 2019; Thompson et al.,

2021), it might be the case that larger operations are less likely to cover crop due to specialization in livestock production relative to crop production. However, for dairies and feedlots, the rate of cover crop adoption appears to vary little with farm size category. Only for cow-calf operations does cover crop adoption seem to vary substantially with farm size; 9 percent of small cow-calf operations used cover crops in 2017, whereas 22 percent of midsize and 24 percent of large cow-calf operations used cover crops. The higher rates of adoption on larger cow-calf operations might be related to constraints on grazing land or forage availability as herd size increases (higher marginal value of cover crop forage) or increased access to labor and equipment necessary to implement cover crops on the operation. Larger operations may also be more likely to have cropland relative to smaller operations—and future research might consider examining the role of livestock operation characteristics in cover crop decisions.

Table 7
Estimated proportion of cattle operations with cropland adopting cover crops by USDA, Economic Research Service farm typology, 2017

Farm typology category	Cow-calf (percent)	Dairy (percent)	Stocking/ backgrounding (percent)	Feedlot (percent)
Small family farms (GCFI less than $350,000)	9	31	15	24
Midsize family farms (GCFI greater than $350,000 but less than $1,000,000)	22	36	19	29
Large family farms (GCFI greater than $1,000,000)	24	33	21	27
Nonfamily farms	15	35	19	26
All categories	11	33	17	27

GCFI = gross cash farm income.

Note: The USDA, Economic Research Service farm typology considers farm size as measured by annual gross cash farm income, which is a measure of the farm's revenue (before deducting expenses). The revenue includes sales of crops and livestock, payments made under agricultural Federal programs, and other farm-related cash income (including fees from production contracts). Nonfamily farms are farms where an operator and persons related to the operator do not own a majority of the business. Dairy operations include all operations with at least 10 milk cows that do not meet the criteria for a cow-calf operation. Cow-calf operations include all operations with at least 20 beef cows in the survey year that do not meet the criteria for a dairy operation. Stocking/backgrounding operations do not meet the criteria for dairies or cow-calf operations, had no cattle on feed at the end of the year, and sold more than 50 head of cattle weighing more than 500 pounds. Feedlot operations do not meet the criteria for any other operation types and had more than 50 cattle on feed at the end of the year.

Source: USDA, Economic Research Service using data from the USDA, National Agricultural Statistics Service 2012 and 2017 Census of Agriculture.

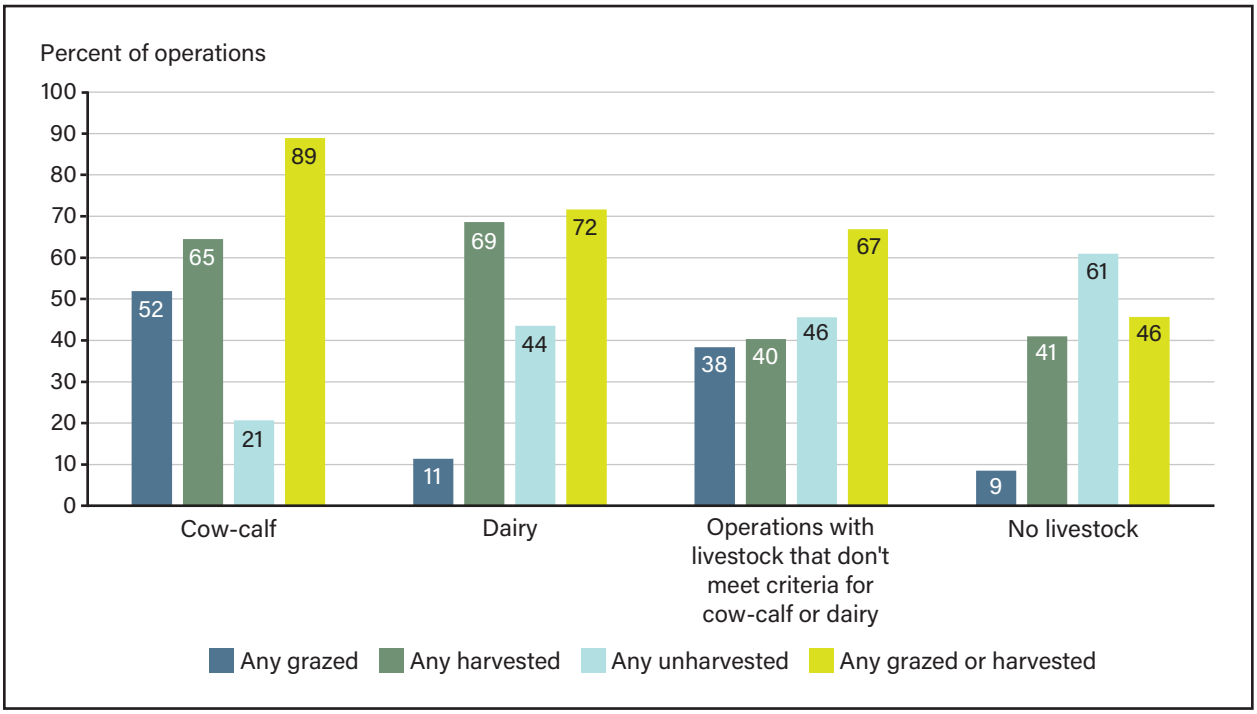
Harvesting and Grazing of Cover Crops Is Relatively Common

To estimate the prevalence of harvesting and grazing of cover crops, the authors analyzed ARMS Phase 3 survey data from 2018–21 to see whether cattle operations (dairy and cow-calf operations) with cover crops report cover cropped acreage harvested for forage or other on-farm use,[19] unharvested cover crops, grazed cover crops, neither, or both. From 2018–20, the survey asked about harvested and unharvested cover crops. In 2021, the survey began asking about cover crops that were grazed but not harvested, cover crops that were harvested, and unharvested cover crops (table 5). Due to these differences in survey questions over time, the authors first presented estimates of cover crop grazing and harvesting from 2021 at the national level in figure 3. The authors then pooled data from 2018–20 and presented statistics on the harvesting of cover crops by

[19] Harvesting cover crops for "forage or other on-farm use" could also include such uses of the cover crop as harvesting the cover crop for cover crop seed. Also, because there was no question specifically asking farmers about grazed cover crops in the 2018–20 USDA, Agricultural Resource Marketing Survey (ARMS) Phase 3 surveys, it is possible that some farmers may be interpreting harvesting of cover crops to include grazing of cover crops. See table 5.

region and livestock operation type.[20] Figure 4 shows the estimated proportion of cow-calf and dairy operations with cover crops by region that reported cover crops as harvested, unharvested, or both.

Figure 3
Proportion of cattle, livestock, and non-livestock operations reporting cover crops that were grazed, harvested for forage, or unharvested, 2021



Note: Dairy operations include all operations with at least 10 milk cows; cow-calf operations include all operations with at least 20 beef cows that calved in the survey year that do not meet the criteria for a dairy operation. Operations report cover crop acreage in each use category, and this table represents the proportion of operations reporting at least some cover crop acreage that was harvested, grazed, or unharvested. Cover crop acreage that was harvested in 2021 may have also been grazed.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA 2021 Phase 3 Agricultural Resource Management Survey.

In the most recent survey year, 72 percent of dairy operations and 89 percent of cow-calf operations with cover crops reported harvesting or grazing at least some of their cover crop acreage for forage in the ARMS Phase 3 survey. And 56 percent of dairies and 79 percent of cow-calf operations reported only cover crops used for forage, either by harvesting or grazing or both. This finding suggests that the forage value of the cover crop is a driver of cover crop adoption for these operations, especially cow-calf operations. Cow-calf operations were more likely to report having cover crop acreage that was exclusively grazed; for dairies, acreage was more likely to be exclusively harvested (appendix tables B.1 and B.2). This finding likely relates to the fact that dairy cows are more often consuming at least a portion of their forage rations in a barn or milking parlor, compared to cow-calf operations, where cattle are more likely to be on pasture or grazing. Even among operations without livestock, the harvesting of cover crops for forage is relatively common; 41 percent of operations without livestock reported harvesting cover crops for forage. Future research might investigate whether these operations are selling hay, silage, or other types of forage harvested from their cover crops.

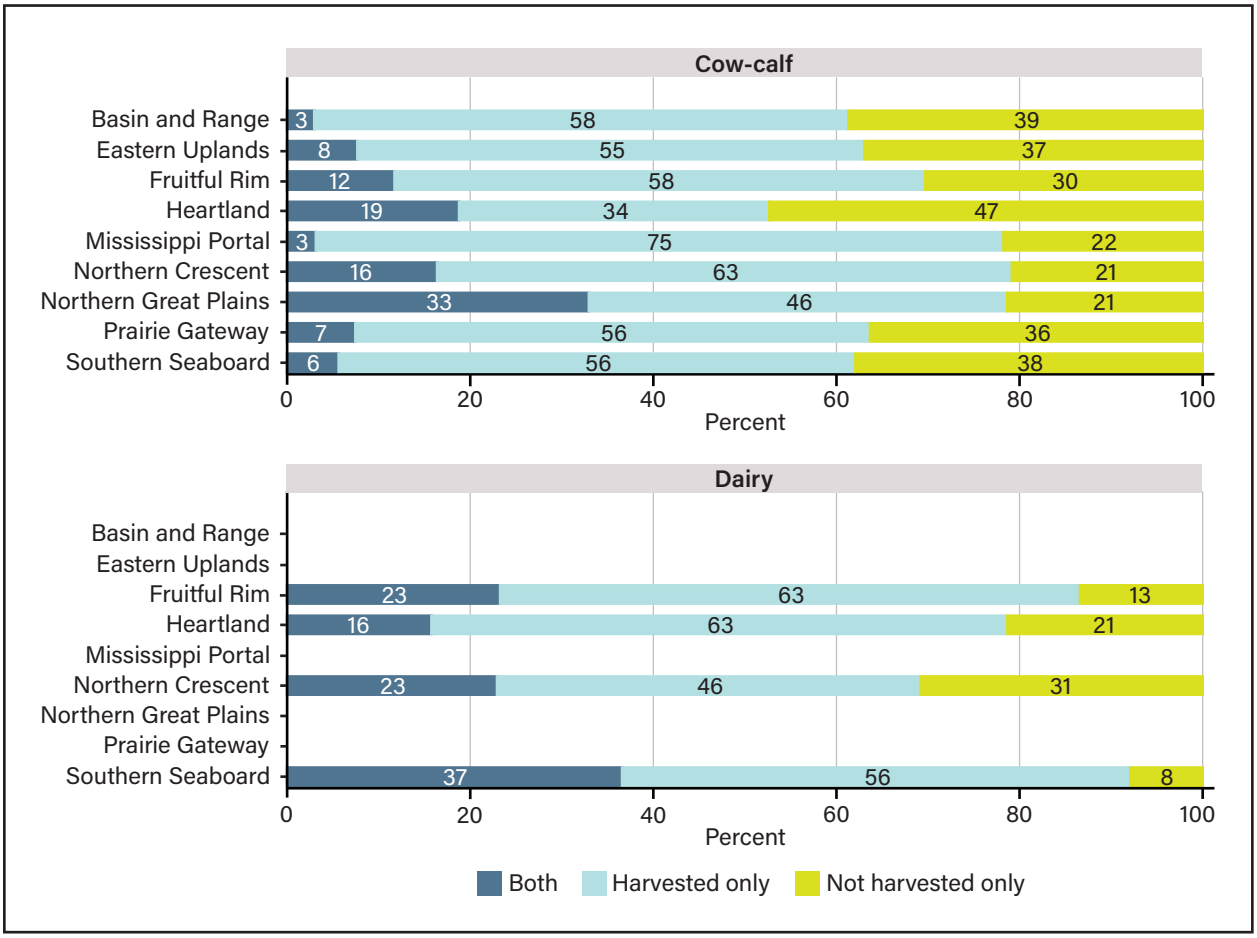
To look at regional differences in cover crop use on dairy and cow-calf operations, the authors pooled data from the ARMS Phase 3 survey from 2018 to 2020 (when the survey questions about use categories were

[20] ARMS Phase 3 does not survey enough feedlot or backgrounding operations to present regional statistics on the operations' cover crop use, so only statistics for dairy and cow-calf operations are presented.

the same but did not include grazing). This was done because, in some regions, the number of operations in different categories in a single year is small, so pooling information over several years allowed for a better estimate of the proportion of operations in each region that were harvesting cover crops, leaving their cover crops unharvested, or that have both harvested and unharvested cover crops. More than half of dairy and cow-calf operations that are cover cropping have at least some cover crop acreage that is harvested for on-farm use in all regions. However, there are regional differences in the prevalence of cover crop harvesting.

Figure 4

Percent of dairy and cow-calf operations with cover crops that are harvesting cover crops, not harvesting cover crops, or planting cover crops that are both harvested and not harvested by USDA, Economic Research Service Farm Resource Region, 2018–20



Note: Dairy operations include all operations with at least 10 milk cows. Cow-calf operations include all operations with at least 20 beef cows that calved in the survey year that do not meet the criteria for a dairy operation. Statistics are not presented for dairy operations in five regions with small numbers of surveyed dairy operations with cover crops. ARMS Phase 3 does not survey enough feedlot or stocking/backgrounding operations to present regional statistics on the operations' cover crop use or harvesting.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, 2018, 2019, and 2020 Agricultural Resource Management Surveys.

For example, the harvesting of cover crops on cow-calf operations is relatively less likely in the Heartland region and relatively more likely in the Mississippi Portal, Northern Crescent, and Northern Great Plains. Dairies in the Northern Crescent region had a larger proportion of operations that reported only unharvested cover crops, which could indicate a larger relative role of regional water quality policies or regulations in livestock operations' decision making in this region. For example, in Pennsylvania, farmers are effectively required to cover crop to apply manure to cropland in the fall after corn silage—so meeting nutrient manage-

ment requirements may be a larger driver for farmers to plant cover crops, independent of whether the cover crops are harvested or used for forage. Although the authors did not report statistics from ARMS Phase 3 data for other types of cattle operations, it's possible that rates of cover crop grazing or harvesting on feedlot operations or stocking/background operations might also be high since cover crops can either be harvested and fed to animals in confinement or directly grazed. For example, feedlot operations may use cover crops to feed recently purchased calves at low cost or to ease the transition from pasture to feed when the calves arrive at the operation (Filbert & Albright, 2021).

What Types of Cover Crops Are Being Used for Forage or Grazing?

Tables A.2 and A.3 in the appendix describe cover crops used for grazing/forage in the research literature and the biomass production, nutritive analysis, and livestock performance associated with different cover crops. Although there are no Federal survey data sources on what cover crops are commonly used for forage or grazing, the ARMS Crop Production Practices survey asks farmers who planted cover crops on their surveyed field to report the type of cover crop planted (in some cases the species and in other cases a more general cover crop category) and how they terminated (killed) the cover crop prior to planting the cash crop.[21]

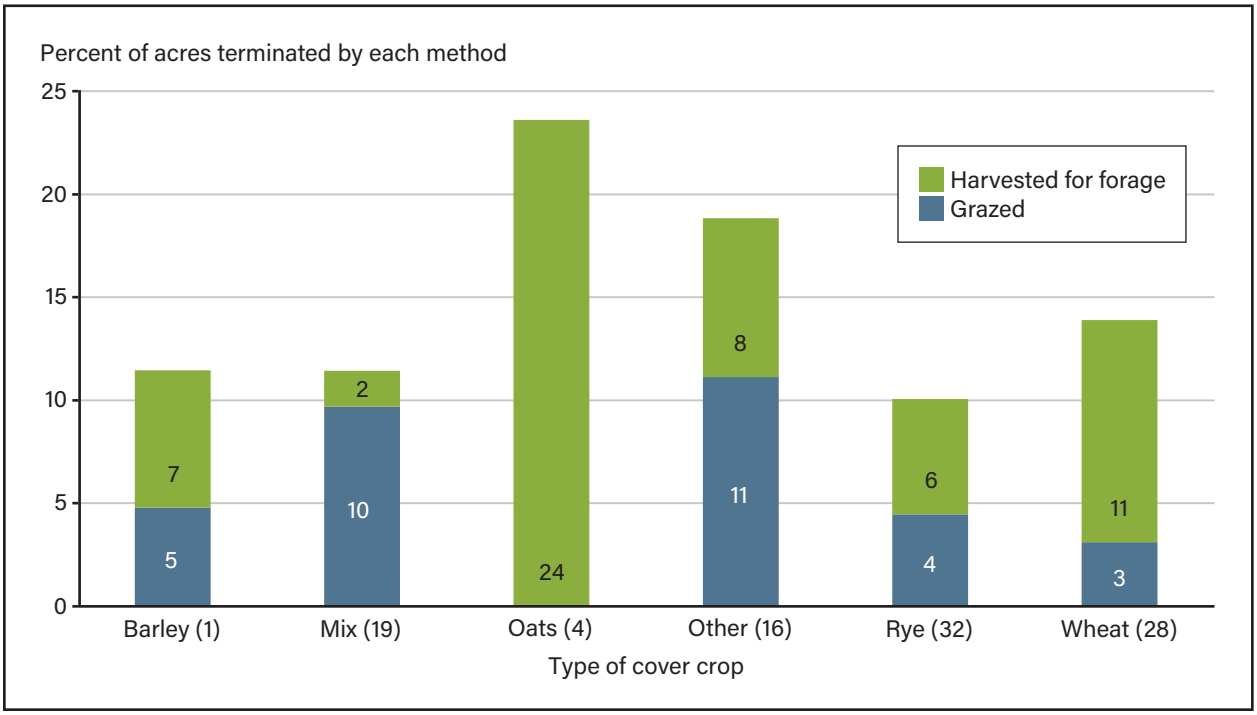
Figure 5 shows the proportion of cover crop acreage where grazing or harvesting for forage was reported as the method of cover crop termination for 2014–17 (planted year) cover crops on 2018 soybean fields, 2015–18 cover crops on 2019 sorghum, cotton, and barley fields, and 2017–20 cover crops on 2021 corn fields. The use of grazing and harvesting for forage as termination methods gives one measure of the variation in how the integration of cover crops and livestock can occur. Across all cover crop categories, grazing/harvesting for forage was the reported termination practice for 13 percent of cover crop acreage. This number is a lower-bound estimate of cover crop and livestock integrations because grazing and harvesting for forage can also happen during the cover crop growth cycle before termination through other methods. The two most common types of cover crops (winter wheat and cereal rye) are more likely to be terminated by harvesting for forage than to be terminated through grazing. In contrast, the third and fourth most common cover crop categories (mixes and other single species cover crops) are more likely to be terminated by grazing. These differences suggest that when integrating cover crops and livestock, farmers are making joint decisions about the cover crop type and termination method.

In figure 6, the authors separated the share of cover crop acreage terminated by grazing or harvesting for forage by the subsequent commodity crop. Termination by grazing or harvesting for forage is more strongly related to the subsequent commodity crop than the cover crop species choice. Most notably, termination by harvesting for forage is three to four times more likely before corn silage and fallow (e.g., when a cash crop is not planted in the fall or following winter). Grazing is relatively more common before crops other than corn, cotton, or soybeans.

[21] If a cover crop was reported as being terminated by grazing, one can assume that the cover crop was grazed—but since grazing of the cover crop can occur at other points during the year in conjunction with cover crop termination by other means, this finding does not fully capture cover crop grazing. Said differently, terminating a cover crop by grazing is a sufficient but not necessary condition to conclude that the cover crop was grazed.

Figure 5

Share of cover crops terminated by grazing and harvesting for forage by cover crop type, 2019–21

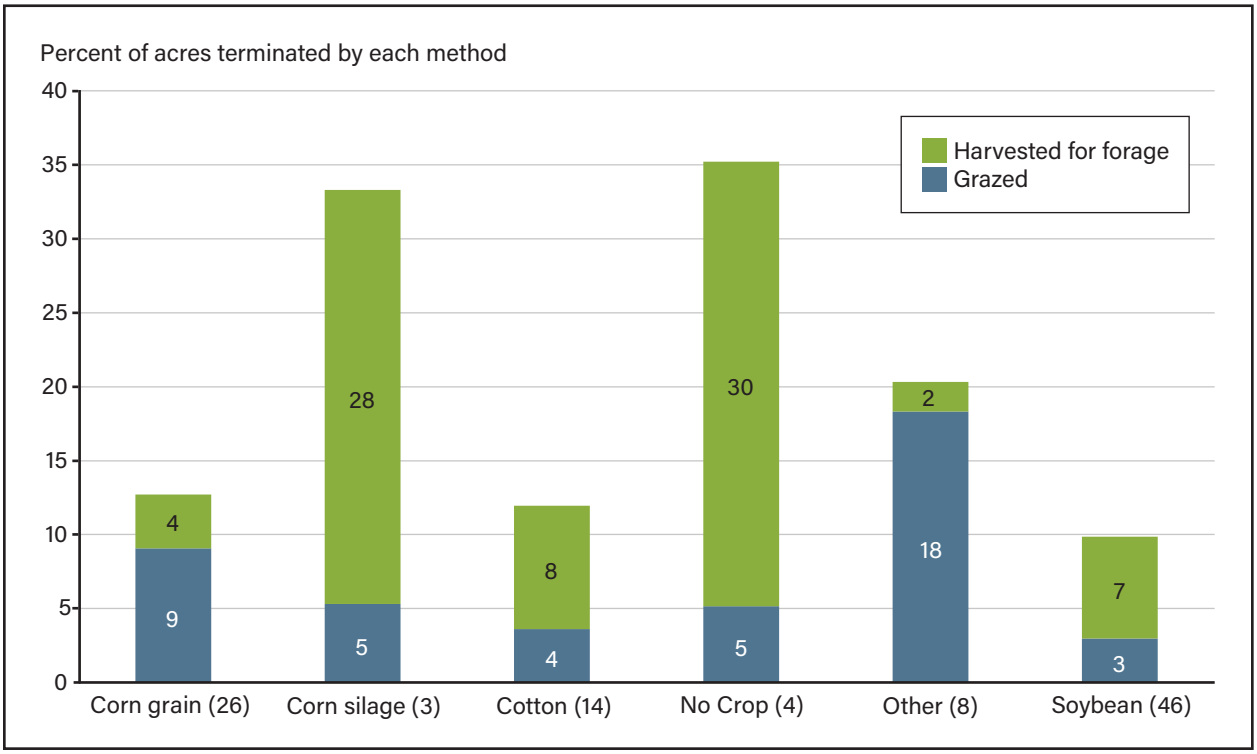


Numbers in parentheses are percent of all cover crop acres. Rye = cereal rye. Other includes ryegrass and grasses including clover, among others.

Note: Statistics represent all observed cover crops over 4 years of crop rotations on sampled fields. The termination method does not preclude grazing or harvesting for forage prior to termination.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, Agricultural Resource Management Surveys in 2019 (soybeans), 2020 (sorghum, cotton, and barley), and 2021 (corn).

Figure 6
Share of cover crops terminated by grazing and harvesting for forage by subsequent cash crop type, 2019–21



Numbers in parentheses are percent of all cover crop acres. Other = all other cash crops reported in survey.

Note: Statistics represent all observed cover crops over 4 years of crop rotations on sampled fields. The termination method does not preclude grazing or harvesting for forage prior to termination.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, Agricultural Resource Management Surveys in 2019 (soybeans), 2020 (sorghum, cotton, and barley), and 2021 (corn).

Expanding Integrated Cover Crop and Livestock Systems

Regional Potential to Expand Integrated Cover Crop and Livestock Systems

Several factors affect when and where farm operations (including operations with livestock) choose to cover crop. One way to assess what areas of the United States might hold the greatest potential to expand the integration of cover crop and livestock systems is to evaluate what regions have higher demand for cover crops for livestock forage but low cover crop adoption. The authors used cattle density per acre of harvested cropland as a proxy for the spatial intensity of livestock forage demand from cover crops on cropland and used cover crop adoption as a proportion of harvested cropland as a metric of intensity of current cover crop adoption. The authors identified counties with a high potential for increased cover crop adoption to meet livestock forage demand.[22] The authors first grouped U.S. counties into one of four categories, as presented in table 8. Following this simple metric, counties with low cover crop adoption and high cattle density might hold a greater potential to expand cover cropping in the context of livestock systems—whereas counties with high cover crop adoption and low cattle density would show a lower relative potential to expand.

[22] The authors suggest that for future analyses, different types of harvested cropland be considered, as the type of cropland has different implications for cover cropping. For example, cropland in perennial crops such as hay or alfalfa would likely not be available for cover cropping. Future analyses may also want to consider adjusting or controlling for regions where there are low absolute levels of harvested cropland, since this cropland may affect either the cattle density or cover crop adoption metrics.

Using this framework, several areas emerged in figure 7 that hold potential for expanded adoption of integrated cover crop and livestock systems. For example, although much of the Southern Seaboard has relatively high adoption of cover crops and therefore lower relative potential for expansion, the Eastern Uplands region, characterized by small farms with mixed crop and livestock systems (e.g., cow-calf and/or poultry production and crop production), shows higher relative potential for adoption due to high cattle density and low cover crop adoption in the 2017 census. Another area showing greater relative potential for increased adoption is in Louisiana and in central/eastern Texas, covering portions of the Mississippi Portal, Prairie Gateway, and western Southern Seaboard regions.

Many counties in the western part of the United States (Fruitful Rim portions of California, Oregon, and Washington, as well as the Basin and Range region) show a relatively high potential for integrating cover crop and livestock systems using this framework. Yet, it is known that precipitation in water-limited agroecosystems (such as the Basin and Range region) limits cover cropping and, in the context of forage production, can limit the quantity and value of forage produced. Thus, despite the high potential for increased adoption in these regions, it's possible that low profitability/barriers to adoption make cover crop and livestock integration less likely. In the Fruitful Rim region, more intensive and high-value production systems or perennial cropland (e.g., orchards) may make cover cropping less feasible or increase the opportunity cost of cover cropping for grazing or forage production on cropland.[23]

Table 8
A simple framework to identify potential for expansion of integrated cover crop and livestock systems, using cattle density and harvested cropland available for cover cropping from the USDA's U.S. Agricultural Census

		Cattle density	
		High (Cattle inventory per acre of harvested cropland > county mean)	Low (Cattle inventory per acre of harvested cropland <= county mean)
Cover crop adoption	High (Percent cover cropped acreage as a proportion of harvested cropland > county mean)	Intermediate	Low
	Low (Percent cover cropped acreage as a proportion of harvested cropland <= county mean)	High	Intermediate

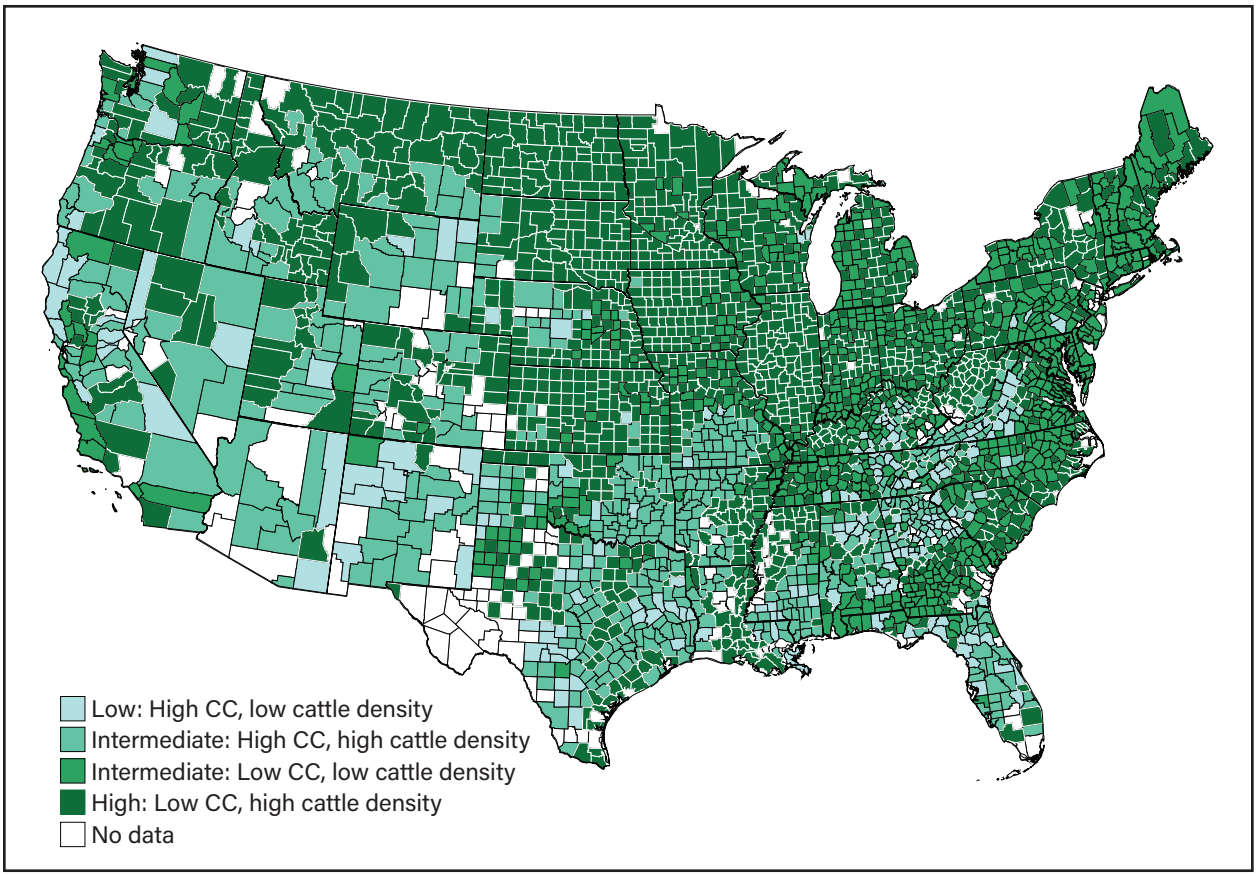
< is less than, > is greater than, <= is less than or equal to, > is greater than.

Note: This table uses relative cover crop adoption and relative cattle density to classify the potential for expansion of cover crop and livestock systems as low (low cattle density and high cover crop adoption), intermediate (high cattle density and high cover crop adoption, or low cattle density and low cover crop adoption), or high (high cattle density and low cover crop adoption). Cover crop adoption is measured as the proportion of harvested cropland that is cover cropped, and cattle density is the cattle inventory per acre of harvested cropland. "High" is above the U.S. county mean for each metric, and "low" is at or below the county mean.

Source: USDA Economic Research Service.

[23] Although cover cropping of whole fields may not be feasible in orchards/vineyards, cover cropping in alleyways/between rows is relatively more common, and the use of livestock other than cattle (for example, grazing of sheep in vineyards) may be better suited to these types of systems (DeVincentis et al., 2020; Ryschawy et al., 2021).

Figure 7
Relative potential to increase the proportion of harvested cropland that is cover cropped for use in livestock systems, 2017



CC = cover crops.

Note: The darker the color, the greater the relative potential to increase the rate of adoption of cover crops for use in livestock systems based upon the criteria in table 8.

USDA, Economic Research Service Farm Resource Regions exclude Alaska and Hawaii.

Source: USDA, Economic Research Service using county-level data from the USDA, National Agricultural Statistics Service 2017 Census of Agriculture.

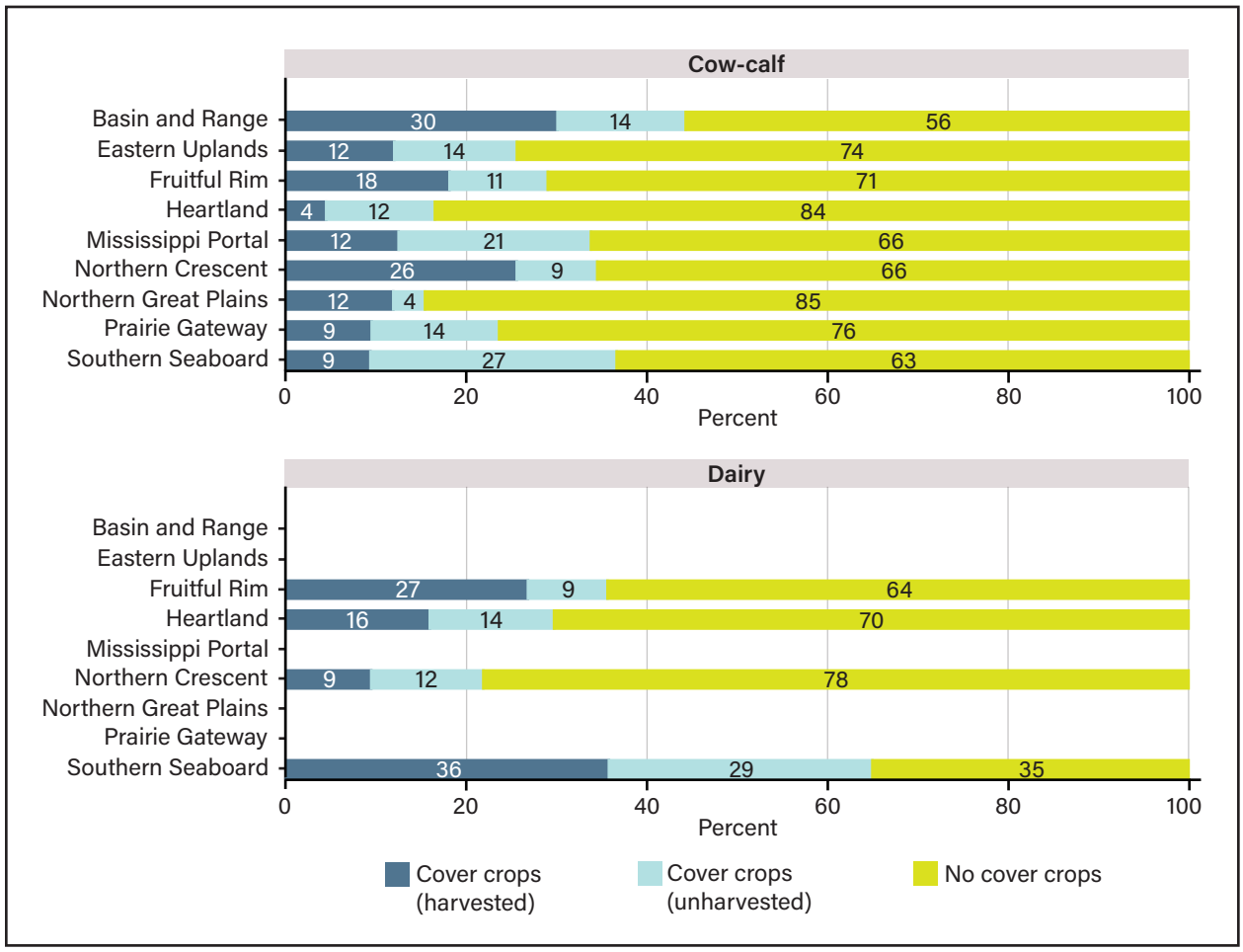
Potential to Expand Cover Cropping for Forage on Cattle Operations Already Planting Cover Crops

One opportunity to expand cover crop use for livestock forage might be to expand grazed or harvested cover crops on cattle operations already planting cover crops. For operations that might be planting cover crops on a large proportion of cropland and harvesting those cover crops for on-farm use, there would be limited opportunities to expand, whereas, for operations with unharvested cover crops or a small share of harvested cover crop acres, there might be greater potential to expand. To estimate the amount of land available for harvesting or grazing cover crops on operations that are already cover cropping, we turn again to the ARMS survey data (figure 8). For farms already planting cover crops, survey data suggest that there is the potential to expand the on-farm use of cover crops through harvesting or grazing. On dairy and cow-calf operations, on average, less than half of cropland is being cover cropped, And, the authors estimated that cover crops are being harvested on 26 percent and 18 percent of cropland on cow-calf and dairy operations with cover crops, respectively. This finding indicates that there could be potential to expand the use of cover crops for forage on

these operations, but could also mean that the extent of cover cropping is limited by suitable cropland, available labor, input costs, or other factors.[24]

On cow-calf operations with cover crops, the estimated share of cropland acres that are cover cropped is lowest in the Heartland, Northern Great Plains, and Prairie Gateway regions—which suggests potential for expansion and cover crop utilization in these regions. However, as discussed in "The economics of integrating livestock and cover crops vary regionally" section, several factors may present barriers to cover crop expansion in these regions, such as water availability or crop rotations that are less conducive to cover cropping.

Figure 8
Proportion of cropland acres cover cropped for dairy and cow-calf operations with cover crops, 2018–20



Note: Dairy operations include all operations with at least 10 milk cows. Cow-calf operations include all operations with at least 20 beef cows that calved in the survey year that do not meet the criteria for a dairy operation. Statistics are not presented for dairy operations in five regions with small numbers of surveyed dairy operations with cover crops.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, 2018, 2019, and 2020 Agricultural Resource Management Surveys.

[24] A reminder that although the 2018-2020 ARMS Phase 3 data do not ask about grazing of cover crops, only 11% of dairy operations with cover crops reported grazing any cover crops in 2021 which could indicate that grazed acreage was a small proportion of cover cropped acreage between 2018 and 2020 for dairy operations.

Conclusion

The literature review in this report suggests that integrating cover crops into livestock systems can be profitable. However, the profitability of growing cover crops for grazing or forage is variable and related to several other geographic and economic factors. These factors include the fixed costs of transitioning to grazing/harvesting cover crops; the level of producer experience; the availability of financial assistance through conservation programs; and regional variability in crop and livestock production systems, soils, and climate (especially precipitation).

Despite the economic potential of integrating cover crops in livestock systems, the authors' analysis of national census and survey data show that a minority of cattle operations with cropland have adopted cover crops. Cattle operations show rates of cover crop adoption similar to all farms with harvested cropland; however, dairy and feedlot operations are more than twice as likely to use cover crops relative to livestock farms with cropland overall (33 percent of dairy operations and 27 percent of feedlot operations in 2017, versus 14 percent of livestock farms with cropland), and there was growth in cover crop use on feedlots between 2012 and 2017. For dairy and cow-calf operations that are planting cover crops, grazing and harvesting for forage is common. In 2021, 72 percent of dairy operations and 89 percent of cow-calf operations with cover crops reported harvesting or grazing at least some of their cover crop acreage. This finding indicates that grazing or harvesting forage may drive the adoption of cover crops in these operations and that it can be profitable.

The authors' analysis also suggested that there is potential to expand the use of cover crops in livestock systems in the United States (for example, in the Eastern Uplands region). Louisiana and central/eastern Texas (covering portions of the Mississippi Portal, Prairie Gateway, and western Southern Seaboard regions) also show potential for expansion. However, areas with low rates of cover crop adoption and high livestock density may face barriers to expanding cover crop use for grazing and forage. For example, in Texas and Louisiana, the total available cropland for cover cropping is limited. The western part of the United States (Fruitful Rim portions of California, Oregon, and Washington, as well as the Basin and Range region) shows relatively high potential for integrating cover crop and livestock systems when considering cover crop adoption and livestock density. However, cover crop expansion is likely limited in these regions due to several factors, including availability of water and cropland and the opportunity costs of cover cropping/forage production in perennial or more intensive/high-value cropping systems.

For dairy and cow-calf operations that are already cover cropping, harvested cover crops represent less than half of the cropland acreage on the operation, on average. This finding indicates that there could be potential for these operations that are already cover cropping to expand the use of cover crops for forage. However, economic barriers to expansion may exist (such as limited labor or forage storage capacity, or seasonal logistical constraints to forage harvest in the spring), and the profitability of expansion is uncertain.

Whether considering cattle operations that are new to cover crops or already working with cover crops, the authors' results also suggest that cover cropping may have greater benefits relative to costs on operations where cover crops are used for forage, either through grazing or harvesting. This finding may have implications for the cost-effectiveness of new or existing programs that pay operations to adopt cover crops.

Finally, this work also highlights several gaps in our understanding of the economics of cover crop use in livestock systems:

- What are the regional economic factors, operation-level variables, and management practices driving producer decisions around grazing and harvesting of cover crops? The USDA, Census of Agriculture does not ask about grazing or harvesting of cover crops, and the ARMS survey only recently began asking if farmers graze cover crops. Additional data on the frequency and extent of grazing of cover

crops would allow us to conduct additional analysis of how (for example) using cover crops for forage relates to other farm operation characteristics, profitability of livestock operations, or farm program participation. With more years of data collection, there may also be larger samples that would allow researchers to look at regional drivers of cover crop grazing and harvesting. In addition, the USDA, Farm Service Agency collects crop acreage reporting data from farmers that increasingly provide detailed information about cover crop use. These data may also provide additional insight into when and where farmers are growing cover crops, what cover crops farmers are growing, and how cover crops are being used on the farm. A related question that might be addressed with existing Federal data would be whether grazing or harvesting of cover crops provides additional benefits in the form of climate resilience or risk reduction at the farm operation level.

- How common is the harvesting of forage crops for sale or off-farm use, or selling or contracting the grazing of a forage crop to another operation? Although this type of harvesting would not meet the definition of a cover crop for some USDA programs, such systems could contribute to environmental benefits (e.g., those associated with conservation-crop rotations), as well as revenue streams for crop and/or livestock operations. In some regions, operations graze a wheat cash crop in the fall or spring that is later harvested in late spring or summer. Understanding the economics of these types of dual-use systems/transactions and potential policy incentives or barriers might provide insight into the potential for further integration of cover crop and livestock systems.

- How does the profitability of grazing or harvesting cover crops vary with different operation-level or management variables? What about geography? Although this report has considered the available literature touching on the economic outcomes of cattle operations that use cover crops for forage, the economic literature assessing the profitability of grazing and harvesting cover crops for forage is limited. Additional survey data and economic analysis could deepen our understanding of not only how common these practices are in the United States but also how they contribute to profitability in U.S. crop-livestock systems.

- What role do Federal programs play in the adoption of cover crop and livestock systems, and how do Federal financial and technical assistance affect incentives for their use? Future survey work and analysis of administrative data (such as NRCS data on programs such as the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP)) may be able to provide some insight on these questions (see box Paying for Cover Crops: Does Experience Change Farmer Incentives?). In addition, analysis of participation in risk management programs such as the USDA, Risk Management Agency's Annual Forage pilot program may help to assess the role of Federal insurance programs in mitigating precipitation risks (especially drought) that impact livestock producers working with annual forages being grown as cover crops.

In this report, the authors provided background and descriptive analysis of the current economics of cover cropping in livestock systems. Through additional analysis targeting specific knowledge gaps the authors identified through this work, researchers and policymakers might better understand the potential for cover crop expansion and integration into livestock systems, the role of Federal financial and technical assistance in overcoming barriers to adoption, and the magnitude of public and private benefits of integrating cover crops and livestock in different regions and farming systems.

Paying for Cover Crops: Does Experience Change Farmer Incentives?

In 2021, the USDA, Economic Research Service began a new project to better understand farmer incentives to plant cover crops. The project will examine the role that USDA financial incentive programs such as the Environmental Quality Incentives Program and the Conservation Stewardship Program play in promoting the adoption of cover crops, as well as how the farmer experience with cover crops affects the economics of cover cropping.

A survey will be conducted across several States to look at:

- Farmers' current cover crop management practices
- Potential barriers to program participation
- Farmer responses to different payment rates for participating, or continuing to participate, in cover crop programs

This work will also provide a better understanding of how differences in operation-level characteristics, such as whether operations manage livestock, affect producer decision making about cover crops.

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Appendix A

Table A.1
Selected findings on the effects of integrated crop-livestock systems with grazed cover crops on soil health and environmental outcomes

Factor	State	Treatment	Effect of ICLS	Source
Environmental changes				
Soil organic C	SD	Non-grazed cover versus ICLS	↓, ↔	Tobin (2020), Kelly (2021)
	CO, KS, NE	Non-grazed no cover versus ICLS	↔	Kelly (2021)
Total N	SD	Non-grazed cover versus ICLS	↑, ↔	Tobin (2020), Kelly (2021)
	CO, KS, NE	Non-grazed no cover versus ICLS	↔	Kelly (2021)
HWC, CWC	SD	Non-grazed cover versus ICLS	↔	Tobin (2020)
B-glucosidase	SD	Non-grazed cover versus ICLS	↔	Tobin (2020)
Bulk density	SD	Non-grazed cover versus ICLS	↑	Tobin (2020), Kelly (2021)
	CO, KS, NE	Non-grazed no cover versus ICLS	↔	Kelly (2021)
Mean weight diameter	CO, KS, NE	Non-grazed cover versus ICLS	↔	Kelly (2021)
	CO, KS, NE	Non-grazed no cover versus ICLS	↔	Kelly (2021)
pH	SD	Non-grazed cover versus ICLS	↔	Tobin (2020)
Electric conductivity	SD	Non-grazed cover versus ICLS	↔	Tobin (2020)
Available water content	CO, KS, NE	Non-grazed cover versus ICLS	↔	Kelly (2021)
	CO, KS, NE	Non-grazed no cover versus ICLS	↓	Kelly (2021)
Permanganate oxidizable C	CO, KS, NE	Non-grazed cover versus ICLS	↔	Kelly (2021)
	CO, KS, NE	Non-grazed no cover versus ICLS	↔	Kelly (2021)
Potentially mineralizable N	CO, KS, NE	Non-grazed cover versus ICLS	↔	Kelly (2021)
	CO, KS, NE	Non-grazed no cover versus ICLS	↔	Kelly (2021)
Phosphorus	CO, KS, NE	Non-grazed cover versus ICLS	↔	Kelly (2021)

ICLS = integrated crop-livestock systems; C = carbon; N = nitrogen; pH = acidity; B-glucosidase = beta-glucosidase

States: CO = Colorado, KS = Kansas, NE = Nebraska, SD = South Dakota.

"↑" = increase, "↓" = decrease, "↔" = neutral effect

Source: USDA, Economic Research Service summarizing findings from sources listed in table.

Table A.2

Summary of findings from the literature of above-ground biomass production and nutritive analysis of cover crop forage

Cover crop species	State	Growing window	Forage produced (pounds per acre)	Nutritive analysis	Source
Rye	GA	Dec. 2–May 7 Nov. 5–Apr. 27 Nov. 10–Apr. 6	5,353 – 6,245		Franzluebbers & Stuedemann (2007)
Pearl millet	GA	June 12–Nov. 15 June 26–Sept. 29 June 22–Sept. 24	6,781–9,100		Franzluebbers & Stuedemann (2007)
Crimson clover Hairy vetch	NC	Sept. 30–May 10	8,565 7,762	-	Jani et al. (2015)
Rye	IL	Planted: October 26 Harvested: May 13	1,071		Blesh & Drinkwater (2014)
Rye	IA	-	-	CP: 18.8–22.0 NDF: 30.1–37.9 ADF: 21.6–28.3	Lundy et al. (2018)
Oats	NE	Sep. 1–early Nov. Sep. 15–early Nov.	2,192; 910	CP: 18, 22.7 NDF: 38.3, 35.9 ADF: 24.0, 21.9	Brinton et al. (2019); Brinton et al. (2020)
Brassicas, Oats, and Sorghum	NE	Aug. 15–last week of October	2,160–3,520	CP: 12.2–19.6 NDF: 35.0–49.1 ADF: 23.1–25.1	Ulmer et al. (2016)
Rye	NE	Oct. 30–Nov. 1 to April 4–May 9	401–3,676	-	Ruis et al. (2017)
Annual ryegrass Oat-rye	OH	Sept. 5–Nov. 20; early April	946–3,042 2,114–3,881	-	Faé et al. (2009)
Brassica	MN	Aug. 17–Oct. 20	1,731–2,320	-	Gieske et al. (2016)
Hairy vetch	PA		3,096	-	Pudget & Drinkwater (2001)

CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber.

States: GA = Georgia; IL = Illinois; IA = Iowa; MN = Minnesota; NC= North Carolina; NE = Nebraska; OH = Ohio; PA = Pennsylvania.

Note: For more information on understanding feed analysis, see Rick Rasby & Jeremy Martin (n.d.).

Source: USDA, Economic Research Service summarizing findings from sources listed in the table.

Table A.3

Summary of findings from the literature of livestock performance on cover crops, 2007–21

Livestock	Initial body weight (pounds)	State	Cover crop species	Grazing days/ season	Average daily gain (pounds per day)	Source
Steer calves	492 ± 14.3	NE	Oats	70; fall/winter	2.36 versus 1.28 ± 0.381 (grazing oats planted after corn silage versus high moisture corn harvest, respectively)	Brinton et al. (2019)
Steer calves	628 ± 2.9	NE	Oat, daikon radish, and purple turnips	66; fall/winter	1.59 and 0.99 ± 0.062 (grazing cover crop versus corn stover, respectively)	Cox-O'Neill et al. (2017)
Heifer calves	481 ± 2.3	NE	Oat-brassica mixture	63; fall/winter	1.68, 1.28, and 1.08 ± 0.09 (grazing cover crop versus corn stover + DDGS versus corn stover + wheat midds, respectively)	Speer et al. (2021)
Steer and heifer calves	447 to 712	IA	Cereal rye	20 to 27; spring	1.42 to 3.10	Lundy et al. (2018)
Steer and heifer calves	518 ± 26.5	GA	Rye	57 to 84; winter	1.90 ± 0.22	Hill et al. (2004)
Cow-calf pairs	Cows: 1,367 ± 37 Calves: 161 ± 7.3	IA	Oats, radishes, and turnips	38; fall/winter	Cows: -0.56 vs. -0.37 ± 0.157 for grazing cover crop versus fed in dry-lot, respectively. Calves: 2.30 vs. 1.44 ± 0.063 for grazing cover crop versus fed in dry-lot, respectively.	Lundy et al. (2018)
Cow-calf pairs	Cows: 1,131 to 1,217 Calves: 152 to 644	GA	Rye	26 to 49; fall/ winter	Cows: -2.09 to 3.20 grazing cover crop with conventional tillage versus 0.60 to 5.34 for cover crop with no tillage Calves: 4.19 to 4.81 versus. 4.65 to 5.40 (grazing cover crop planted with conventional tillage versus. No tillage, respectively)	Franzluebbers & Stuedemann (2007)
Cow-calf pairs	Cows: 1,093 to 1,182 Calves: 401 to 675	GA	Pearl Millet	31 to 77; summer	Cows: -1.21 to 4.89 when grazing cover crop planted with conventional tillage versus -0.18 to 3.81 with no tillage Calves: 3.84 to 4.28 versus 4.17 to 4.81 (grazing cover with conventional tillage versus no tillage, respectively)	Franzluebbers & Stuedemann (2007)

States: GA = Georgia; IA = Iowa; NE = Nebraska.

Source: USDA, Economic Research Service summarizing findings from sources listed in table.

Appendix B

Table B.1

Estimated percentage of dairy operations with cover crops by cover crop use categories reported (harvested, unharvested, and/or grazed), 2018–21

Cover crop use	Percent by year			Cover crop use	Percent
	2018	2019	2020		2021
Harvested only	37	47	57	Harvested only	48
Mix of harvested and unharvested	24	29	19	Mix of grazed and harvested	-
				Mix of grazed and harvested and unharvested	-
				Mix of harvested and unharvested	13
Unharvested only	40	24	25	Grazed only	-
				Mix of grazed and unharvested	-
				Unharvested only	28

Note: Dairy operations include all operations with at least 10 milk cows. Operations report cover crop acreage in each use category, and this table represents the proportion of operations reporting at least some acreage in one or more cover crop use categories. The use categories in 2018–20 were harvested and unharvested, and the use categories in 2021 were harvested, grazed, and unharvested. Cover crop acreage harvested in 2021 may have also been grazed. "Harvested" in 2021 stated "harvested for forage," whereas "harvested" prior to 2021 stated "harvested for forage or other on-farm use," which could include cover crop seed or other uses. An estimated 11 percent of Dairy operations report grazing cover crops in 2021, but the sample size is too small to report estimated statistics for categories that have a dash in the 2021 column.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, 2018–21 Phase 3 Agricultural Resource Management Surveys.

Table B.2

Estimated percentage of cow-calf operations with cover crops by cover crop use categories reported (harvested, unharvested, and/or grazed), 2018–21

Cover crop use	Percent			Cover crop use	Percent
	2018	2019	2020		2021
Harvested only	42	56	51	Harvested only	34
Mix of harvested and unharvested	10	15	14	Mix of grazed and harvested	23
				Mix of grazed and harvested and unharvested	4
				Mix of harvested and unharvested	3
Unharvested only	49	29	35	Grazed only	22
				Mix of grazed and unharvested	2
				Unharvested only	11

Note: Cow-calf operations include all operations with at least 20 beef cows that calved in the survey year that do not meet the criteria for a dairy operation. Operations report cover crop acreage in each use category, and this table represents the proportion of operations reporting at least some acreage in one or more cover crop use categories. The use categories in 2018–20 were harvested and unharvested, and the use categories in 2021 were harvested, grazed, and unharvested. Cover crop acreage harvested in 2021 may have also been grazed. "Harvested" in 2021 stated "harvested for forage," whereas "harvested" prior to 2021 stated "harvested for forage or other on-farm use," which could include cover crop seed or other uses.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, 2018–21 Phase 3 Agricultural Resource Management Surveys.