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Evolving conceptions of silvopasture among farmers and natural resource professionals in Wisconsin, USA

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Silvopasture has gained attention as an agroecological practice that may simultaneously meet farmer goals and provide environmental benefits, including climate change mitigation. At the same time there are significant concerns about the potential for livestock to damage trees and forest soils. Like other innovative agroecological systems, silvopasture combines management complexity with limited research knowledge. Unlike annual crops, the effects of silvopasture management can take decades to assess and require forestry as well as agronomic expertise. We conducted mixed-methods research on silvopasture attitudes and knowledge among farmers, agricultural advisors, and foresters in Wisconsin between 2014 and 2019. We asked: (1) How do farmers who practice grazing, agricultural advisors, and foresters perceive silvopasture? and (2) How did coverage of silvopasture change between 2009 and 2019 in a popular grazing publication? Perceptions of silvopasture were influenced by recent weather history, markets for forest and agricultural products, existing land uses, and other contextual factors. Some farmers and agricultural advisors were committed to silvopasture despite significant obstacles to implementing the practice. Over the course of the study period agricultural advisors increased their willingness to provide silvopasture advice to farmers and professional colleagues, and coverage of silvopasture increased in a popular grazing publication. Finally, a multi-county supportive community of practice was associated with greater enthusiasm for the practice. The greater acceptance of silvopasture among resource professionals follows an increase in silvopasture research and outreach in the region. This interest in silvopasture suggests both a need for, and openness to, greater collaboration among forestry and agricultural professionals and farmers to develop sustainable silvopasture standards.

KEYWORDS

adoption, agroforestry, Midwest, human dimensions, silvopasture, agroecology

1. Introduction

The predominant agricultural model of annual row crop monocultures and bare ground seasonal fallow pollutes surface and groundwaters and causes a host of other environmental and social problems (Porter and Voskuil, 2022). In contrast, strategies for providing continuous living cover aim to significantly improve water quality, habitat, aesthetics, and other environmental and social outcomes, while continuing to provide the food, fiber, and fuel society demands (Green Lands Blue Waters, n.d.). One such continuous living cover strategy is silvopasture, an agroforestry practice that intentionally integrates livestock, forage production, and trees.

Shifting annual row crop systems to continuous living cover first requires people to change their ideas about, and goals for, agriculture. Some continuous living cover strategies, like growing cover crops to replace the seasonal fallow, require relatively modest changes to existing annual cropping systems and keep the principal crops, equipment, and planning timelines in place. Even modest agricultural system changes are challenging, though, and as a result the acreage managed by farmers who have shown interest in cover crops far outstrips the amount of land actually planted in cover crops. At the other end of the spectrum of continuous living cover strategies, agroforestry practices such as silvopasture involve major systems changes, including very different crop types (trees and shrubs) and planning timelines of decades. Making these major changes calls for a profound shift in thinking and action on the part of farmers, resource professionals, and policy-makers. This study examined perceptions of silvopasture in Wisconsin from 2014 to 2019.

Within the US, silvopasture systems integrating beef cattle with fast-growing southern pine plantations have been most widely adopted and most studied (Clason, 1998; Ares et al., 2003; Grado and Husak, 2004; Shrestha et al., 2004; Nair et al., 2007; Cabbage et al., 2012). Garrett et al. (2004) proposed silvopasture as a practice that can improve water quality and other environmental outcomes and profits compared to the widespread practice of unmanaged grazing of woodlands in the upper Midwest, while maintaining or increasing meat or milk production (see also Ford et al., 2019). Silvopasture is also seen as an approach to increase carbon storage and reduce the net climate change impacts of agriculture, as well as increase resilience to weather extremes (Montagnini and Nair, 2004; Howlett et al., 2011; Baah-Acheamfour et al., 2014, 2016; Hawken, 2017; Patel-Weynand et al., 2017).

At the same time, there is a long history of natural resource professionals opposing the integration of livestock with trees, especially in western Europe and the US (Dambach, 1944; Ahlgren et al., 1946; Guise, 1950; Abbott, 1954). This opposition stems in part from situations where livestock damage forests, but it also coincided with the professionalization of forest management and the associated assumption that the best use of a forest is to produce timber (Dana and Fairfax, 1980; Rubino, 1996). Forestry professionals continue to be more skeptical of and less knowledgeable about silvopasture than agricultural advisors and farmers. The latter two groups are more likely to support silvopasture, while acknowledging that livestock can compact soil and create erosion (Arbuckle, 2009; Mayerfeld et al., 2016; Stutzman et al., 2019).

Most of the social science research on silvopasture in temperate regions has focused on economic analysis, silvopasture knowledge of resource professionals, and stakeholder perceptions of benefits and costs (Shrestha et al., 2004; Frey et al., 2012; Mayerfeld et al., 2016; Orefice et al., 2017a; Blanco et al., 2019; Wilkens et al., 2022). Stakeholders usually perceive shade and shelter for livestock as key benefits of including trees in the grazing system. Increased income is another widely cited benefit, although in some cases the income benefits are expressed indirectly, for example as “increased utilization of farm woodland” (Orefice et al., 2017a). Reports of silvopasture challenges or disadvantages are less consistent, but problems with maintaining fences and lack of knowledge about silvopasture management are key concerns. Frey et al. (2012) addressed changes in perceptions over time; they reported that farmers in Argentina perceived more benefits and had fewer concerns

about silvopasture after they had several years of experience than when they were first considering the practice.

Following the suggestion of Garrett et al. (2004) that silvopasture may improve environmental and economic outcomes in woodlands degraded by poor management, researchers in the Midwest and Northeastern US began to study silvopasture establishment in existing woodlands (Demchik et al., 2005; Orefice et al., 2017b, 2019; Ford et al., 2019). Many of the farm woodlands in these regions are or were grazed, and much of the existing pasture is in woodlands.

Agroforestry proponents distinguish silvopasture (in which trees, forages and livestock are actively managed for economic and environmental outcomes) from woodland grazing by noting that the latter involves little or no deliberate management of the forage layer, the trees, or the timing and intensity of livestock use (Brantly, 2014). The limited information available indicates that management of pastured woodland (the term used by the Agricultural Census) varies, but that in most cases it is not managed intensively enough to be characterized as silvopasture. In Wisconsin and most surrounding states, the number of farms with pastured woodland exceeds the number of farms practicing rotational grazing, and greatly exceeds the number of farms using agroforestry practices including silvopasture as well as forest farming, windbreaks, alley cropping, and riparian buffers (Figure 1). Across the US, 326,279 farms had pastured woodland, 265,162 farms practiced rotational grazing, and only 30,853 farms practiced agroforestry in 2017 (USDA-NASS, 2019a,b).

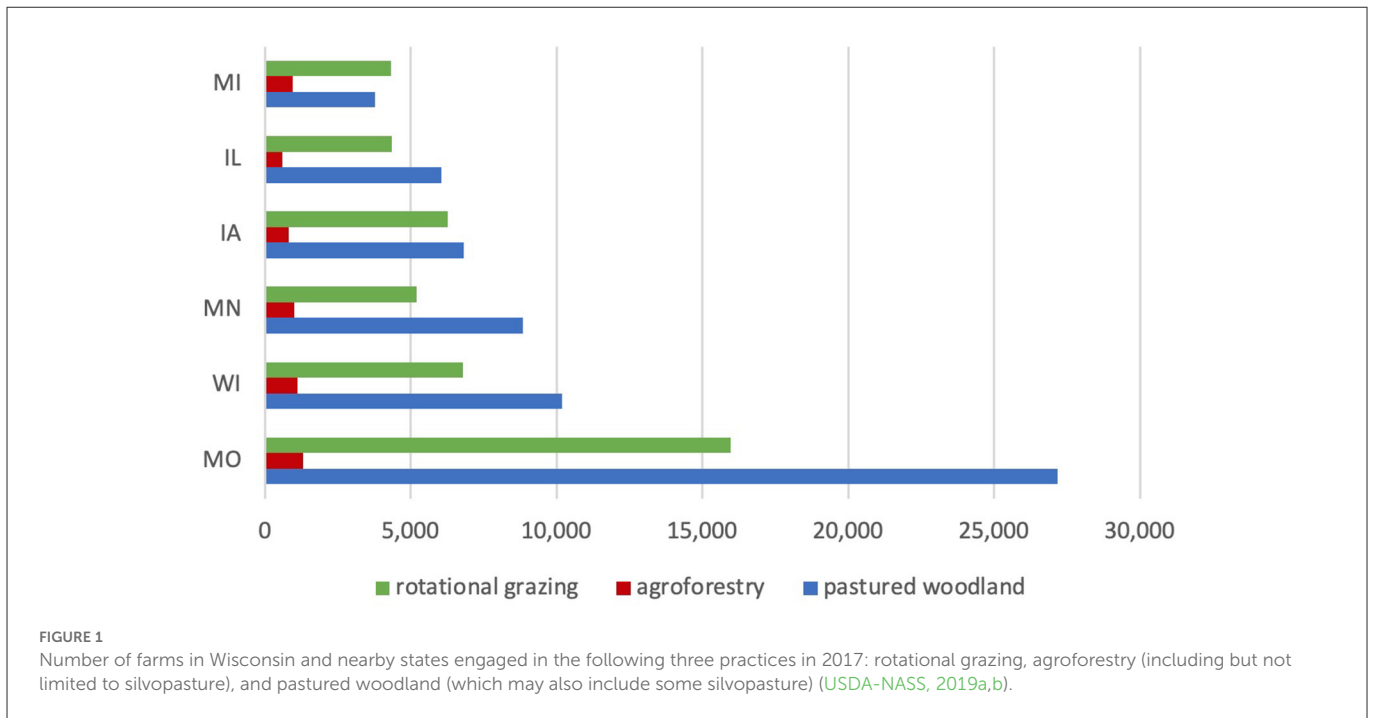
Although some farmers practice silvopasture without knowing the technical term, farmers and natural resource professionals in Wisconsin report that most cases of woodland grazing do not include active management of the forage or trees (Keeley, 2014; Mayerfeld et al., 2016; Galleguillos et al., 2018). Only 23% of Wisconsin farms with pasture practice rotational stocking, a necessary component of silvopasture management in this region, and likely only a subset of those farms manage their rotation intensively (USDA-NASS, 2019b; Whitt and Wallander, 2022).

In this context of complexity, controversy, emerging research, and extensive woodland grazing where silvopasture could potentially be practiced, we examined attitudes toward and knowledge about silvopasture during the 6 years following the initiation of silvopasture research and outreach in and around Wisconsin. Specifically, we asked two research questions:

1. How do farmers who practice grazing, agricultural advisors, and foresters perceive silvopasture?
2. How did the amount and type of coverage of silvopasture change between 2009 and 2019 in a popular grazing publication?

2. Methods

This is a descriptive, exploratory mixed-methods study (Byrne and Ragin, 2009; Yin, 2009). To assemble our case, we used (1) focus group and individual interviews clustered in two regions, (2) end of program evaluations, (3) content analysis of a popular grazing publication, and (4) participatory observation. This approach allowed us to examine silvopasture attitudes and knowledge in context, examine interactions among factors, and in some cases observe changes over time. Research with human subjects was approved by the UW-Madison Institutional Review Board (# 2015-1521).



The subjects of our study were three categories of silvopasture stakeholders in Wisconsin: *farmers*, *agricultural advisors*, and *foresters*, with the latter two categories referred to collectively as *resource professionals*. We focused our study on southwestern and northwestern Wisconsin, but also included stakeholders throughout the state.

In 2014, we began interviewing farmers, agriculture advisors, and foresters about their views on integrating livestock grazing with trees. In their capacities as educators, two of the authors (one with University of Wisconsin Extension and one with the Savanna Institute, an NGO focused on agroforestry research and education) also began conducting educational outreach about silvopasture in 2014. In 2015, we initiated two silvopasture research trials: one on a university research station and the other on two commercial farms. Our work occurred in the context of other agroforestry outreach and research in the region and nationwide. For most farmers and resource professionals in Wisconsin, the workshops, conference presentations, and pasture walks we helped organize were a major source of silvopasture exposure.

2.1. Interviews

We conducted 12 focus group interviews with farmers, agricultural advisors, and foresters between 2014 and 2019 (Table 1). We also conducted individual interviews with two agricultural advisors, a forester, and five farmers who could not participate in the focus groups but were interested in contributing to the project. The focus group interviews form the foundation for our case study. The individual interviews supplemented the focus group interviews and provided a check that there were not issues and questions that participants hesitated to bring up in a group setting.

To some extent, the results of the six focus group interviews in 2014, 2016, and September 2017 serve as a baseline of silvopasture knowledge and attitudes early in the study period. In these initial interviews we asked the participants for their thoughts about integrating grazing livestock with trees and about silvopasture. Although the September 2017 interview took place more than 3 years after the start of the project, the participants were all foresters with whom we had no previous interactions, and for whom our questions about silvopasture were novel.

The four focus group interviews conducted in 2018 and 2019 included 12 individuals who had participated in earlier interviews, as well as at least six individuals who had participated in one or more silvopasture events, such as a pasture walk or presentation. In these later interviews we added prompts asking participants where they had first heard about silvopasture and asking them to reflect on changes in silvopasture knowledge, attitudes, and practices in the past 5 years.

The focus group interviews conducted in January and March 2017 were intermediate in nature. We had not interviewed the participants before, but they were aware of our work, and some had attended a silvopasture event before the interview. Like the individual interviews, they supported the findings of the early focus groups.

Our interviews were clustered in two regions, northwestern and southwestern Wisconsin. The northwestern region is a relatively level landscape shaped by glaciation, with agricultural systems limited by a short growing season and low natural soil fertility. In contrast, southwestern Wisconsin is located in the unglaciated Driftless Area, which has steep topography, making it marginal for large-scale row crop production. Both areas contain substantial woodland, primarily mixed hardwoods and a few small red or white pine plantations. In southwestern and northwestern Wisconsin counties woodland accounts for 15–36% of total farmland (USDA-NASS, 2019a). Roughly 30% of farms have beef cattle, and 6–21% of farms have dairy cows.

TABLE 1 Focus groups dates and participants.

Year	Month	# people*	Male	Female	Farmer	Ag. advisor	Forester	Other
2014	Feb	8	4	4	2	2	5	1
2014	March	2	1	1		2		
2014	May	7	7	0	7			
2016	March	12	8	4	12	1		
2016	Oct	5	3	2		5		
2017	Jan	3	2	1	3			
2017	March	2	2	0	1		1	1
2017	Sept	9	9	0	1		9	
2018	Sept	8	8	0	8**			
2018	Nov	12	9	3	12			2
2019	Jan	7	5	2	2	4	2	1
2019	Feb	6	6	0	5	2		

*The sum of farmers, foresters, and agricultural advisors exceeds the total number of interviewees because several of the natural resource professionals also farm.

**This focus group took place outdoors after a pasture walk, and participants did not fill out a demographic form, but all described themselves as farmers in introductions.

2.1.1. Interviewees

Participants in the five focus groups conducted in 2014 and 2019 were invited based on their experience operating grass-based farms or as resource professionals. The other seven focus groups took place in the context of conferences or pasture walks and were open to any event attendees who chose to participate.

Participant ages ranged from under 30 to over 70, and length of time in their current position (including farming) ranged from <2 years to more than 50 years. The amount of land farmers had in woodland was highly variable, from no woods on the farm to the majority of land in woods, with many respondents having between 10 and 50% of their land in woods. Thirty-three participants managed beef or dairy cattle; five managed sheep, goats, poultry, bison, or pigs. We recruited farmer participants through grazing networks, so the farmers we spoke with practiced rotational stocking (also known as rotational grazing, managed grazing, or adaptive multi-paddock grazing). Because rotational stocking is a requirement for silvopasture management in this region, farmers who practice grazing are the most likely group to try silvopasture. Education levels ranged from high school (10th grade) to graduate degrees in the farmer focus groups.

The farmers participating in the focus groups had a range of experience with and attitudes toward silvopasture. Each farmer focus group had at least one farmer who had no trees in their pastures, as well as at least one farmer who was managing pasture with trees.

Agricultural advisors included university extension, public agency [e.g., Natural Resources Conservation Service (NRCS)], and non-governmental organization (NGO) staff, and grazing consultants or technical service providers (TSPs). Foresters included university extension and Wisconsin Department of Natural Resources staff and private foresters. All resource professional respondents had a 4-year college degree or higher.

2.1.2. Interview structure and analysis

For the interviews, we used guiding questions but also allowed the conversation to flow naturally and encouraged respondents to interact with each other as well as the interviewer(s). All focus

group interviewees consented to having the session recorded, but the recorder malfunctioned at one focus group.

Transcripts from the 2014 to 2017 focus groups were coded manually using a grounded theory approach (Morgan et al., 2008). Focus groups in 2018 and 2019 were coded manually according to the categories that emerged from the initial coding, as well as their responses to a new prompt about changes in knowledge and attitude. Our interview analysis focused on qualitative identification of issues, attitudes, and connections rather than attempting to assess the relative importance of themes through number of mentions or other quantitative measures.

2.2. Evaluation

During the study period we conducted numerous educational programs on silvopasture in Wisconsin, including seven statewide conference presentations, four pasture walks in southwestern Wisconsin, and three 2-day workshops (one in northwestern and two in southwestern Wisconsin and southeastern Minnesota), as well as media interviews and other events. We used end of program evaluation forms at all the workshops, three pasture walks, and two conferences to collect information from participants about their perceptions of silvopasture, as well as their silvopasture information sources and needs. These evaluation results supplement the interview findings.

2.3. Content analysis

Graze magazine focuses on grazing advice, and both farmers and agricultural professionals use it as an information source. The magazine is headquartered in Wisconsin and has been reaching an audience of farmers using managed grazing since 2000. It has ~2,000 paid subscribers across the US, Canada, and overseas, with high concentrations of readers in the Upper Midwest and Northeast states. We conducted a summative content analysis of *Graze* from January

2009 to May 2019 for several terms that we thought would appear in any discussion of silvopasture or integration of livestock with trees (Hsieh and Shannon, 2005). The search terms we used were “shade,” “silv”¹, “tree,” “wood,” “heat,” “brush,” “forest,” and “shrub.” We only counted instances of the term that related to the integration of livestock with trees. In addition to noting when and how often the topic of trees in grazing systems came up, we assessed how trees were discussed. This analysis provided an additional window on attitudes toward silvopasture, as well as the availability of silvopasture information in the farming community. In contrast to the interview analysis, this content analysis includes a quantitative component.

2.4. Note on author engagement

During the study period authors DM and KK also conducted silvopasture field trials in southwestern Wisconsin, and we organized and presented at a variety of silvopasture outreach events. Thus, we were actively engaged in discussions around silvopasture in the state at the same time that we were conducting this study. Our roles as researchers and educators likely influenced who was willing to be interviewed and may have affected what interviewees said. Our active participation in silvopasture research and outreach allowed us to observe conversation around silvopasture beyond the formal methods of interviews and written evaluation responses.

3. Results

3.1. How do farmers who practice grazing, agricultural advisors, and foresters perceive silvopasture?

3.1.1. Farmer perceptions and knowledge

Throughout the study period farmers expressed a range of attitudes toward silvopasture, from uncertainty about its environmental and economic sustainability on their farms to strong enthusiasm for the practice. We did not observe an overall shift to more positive or more negative perceptions among farmers, but we did see differences in how farmers discussed silvopasture at different times, depending on individual farm experience and wider contextual factors.

In all the focus groups, farmers who had been managing silvopasture on their land demonstrated their knowledge by talking about specific management practices and observations based on their experience. In the group interview setting, farmers who did not have personal silvopasture experience did not portray themselves as having silvopasture knowledge, even though some of them mentioned having read or heard about the practice. Often farmers in the focus groups avoided using technical language, including the term silvopasture, even when they were familiar with the terminology.

Several topics appeared in all the interviews: the potential impact of silvopasture on animal welfare, farm profitability, soil and water quality, biodiversity, and the presence of shrubs. However, at the later focus groups there were some shifts in emphasis that reflected changes in the broader farm economy and recent weather patterns

TABLE 2 Overview of silvopasture knowledge and attitudes in Wisconsin USA and surrounding states from 2014 to 2019 interviews with farmers, agricultural advisors, and foresters; evaluations following educational events; and content analysis of a popular grazing publication.

Finding	Patterns and trends
Attitude: A relatively small but dedicated set of farmers is interested in exploring silvopasture (3.11, 3.12)	<ul style="list-style-type: none"> • Farmers’ confidence with silvopasture management depended on their goals and own farm experience. • Farmers’ and resource professionals’ attitudes toward silvopasture were influenced by local context, such as timber markets and recent weather, and by participation in communities of practice.
Attitude: The taboo around silvopasture is weakening, and some agricultural advisors began to provide silvopasture advice (3.12, 3.2)	<ul style="list-style-type: none"> • Early in the study period resource professionals did not address silvopasture in their work. Late in the study period some agricultural advisors gave silvopasture advice, and some foresters were open to considering silvopasture applications. • Coverage of the benefits of trees in pasture systems increased during the study period in a popular grazing publication.
Knowledge: Silvopasture management is more complex, and site- and goal-specific than the dominant grain and livestock systems in the region (3.11, 3.13)	<ul style="list-style-type: none"> • Throughout the study period silvopasture variability and uncertainty continued to challenge resource professionals. • Farmers and agricultural advisors are experimenting with silvopasture to meet goals such as shade and shelter for livestock, brush management, and increased forage. • There is demand for locally-relevant information about silvopasture management, economics, and environmental impacts.

and increased knowledge about silvopasture on the part of both farmers and resource professionals. Key research findings from interviews, as well as from written evaluations following educational events and content analysis of a popular grazing publication, are summarized in Table 2.

Most of the discussion in our farmer interviews centered on conversion of existing farm woodlands to silvopasture, although at least three of the farmers interviewed had planted trees in their pastures. None of the focus group participants expressed direct opposition to silvopasture.

3.1.1.1. Farmer perceptions of benefits and concerns with silvopasture

Key benefits interviewees associated with silvopasture were shade and shelter for livestock; the potential for increased income because of additional pasture, harvest of forest products, and/or lower property taxes associated with converting woodland to silvopasture²; and reduction of brush (i.e., understory shrubs that obstruct herbaceous forage growth, passage and visibility). Concerns included the potential for damage to trees and soils, as well as increased

1 We used “silv” to capture alternative spellings, e.g., silvopasture or silvopasture or silvopasturing or silvopasture.

2 Unlike most states, Wisconsin property tax law assigns the lowest tax rate to “wooded pasture” (Wisconsin Department of Revenue, 2022).

labor to maintain fences and manage the forage layer when trees are present.

These benefits and concerns reveal interactions and some tensions among shared norms and individual values, constraints, and experience. Take these comments from a farmer in a focus group in 2016. Early in the focus group we asked all the farmers to comment on whether they were currently integrating their grazing with trees or considering it. One farmer explained

I have pigs and am interested in feeding the pigs acorns. I've been bringing the pigs acorns because I know that the pigs can really tear up an environment. I have a lot of closed woods with really nice trees and wouldn't dare let the pigs go there. But this little segment that was logged. It has some nice scattered oaks, ... but what's filling in between them is popple, little tiny popple [*Populus sp.*]. Four inches apart – you can't even walk through it. ... I suppose if you're a woodcock it's wonderful. If I were going to move a hog under an oak tree it would be on that piece right there. And then with the hopes that ... I could turn this stand into silvopasture with these sparse oaks if I can get rid of the popple, which I'm sure a hog can do. ... It seems like a good idea, but I'm not sure. ... Most people would say you're not ruining a great field or anything. But there could be something wonderful in there – I don't know.

After an hour of discussion among the 11 farmers in the group, ranging from the animal welfare and tax benefits of silvopasture to its potential impacts on forest soils and trees, this same farmer was still struggling to reconcile the norms and values of providing animal welfare, running a profitable farm, and caring for the environment:

You're rich in direct proportion to the things you can afford to leave alone. And I'm very cautious. When I talk about doing this with hogs – soil science guy says watch out for damage – well leaf cover looks like soil cover to me – things look pretty healthy [as they are now] ... should I even mess with it? That [good woods] is off limits to me; I only toy with the idea of the popple growth. But then woodcock would love that popple.

Hogs embody the conflicting norms around silvopasture particularly strongly because they are highly sensitive to heat stress and thus can benefit from shade, but are also very likely to cause severe soil disturbance because of their rooting behavior. Farmers in all the focus groups spoke about the differences between livestock types, as well as other factors that could affect silvopasture success on a specific farm:

“Question for those using trees at the edge [of fields]: are those trees dying? Ours haven't. Oak, maple, little bit of silver popple.”

“Where my trees are, they're tamarack, and [the livestock] rubbed the bark all off, and they're dying.”

“If you don't have enough trees and you leave them [the livestock] in long enough, yes, they will [kill trees]. The trick is don't leave them in there very long... I notice my oak trees grow really fast now that there are animals in there. ... Less competition, more sunlight. Clover, meadow fescue, orchardgrass, some red clover in the open areas. It's my best pasture in the summertime, during the drought.”

3.1.1.2. Knowledge-exchange networks, farmer experience, and perceptions of silvopasture in socio-ecological context

The practice of silvopasture is of potential interest to livestock farmers who use grazing as a management practice, and the farmers we interviewed were active in networks that promote rotational stocking. We did not collect information on the details of their grazing management, such as frequency of moves, stocking density, and length of rest periods. In Wisconsin a typical rotation schedule for most grass-based lactating dairy cows involves daily moves over an approximately 30 day rotation. For rotationally grazed beef cows, dairy heifers, dry cows, and small ruminants time in a paddock varies depending on a variety of factors, but is often determined by forage residual height goals. Farmers are advised to size paddocks so the animals will be moved every few days and at least weekly to avoid overgrazing (Cavadini, 2022).

In all the focus groups, farmers emphasized careful management of grazing timing, intensity, and duration as important to mitigating negative impacts on the soil and plants, as well as maintaining the performance of their livestock. Because the timing and duration of grazing is a critical component of silvopasture management, farmers who practice rotational or adaptive multi-paddock grazing are well-positioned to implement silvopasture. Within this group of potential adopters, a subgroup is actively interested in learning about and implementing silvopasture. Although the practice remains poorly understood and adds significant management complexity, that subgroup of interested farmers remained engaged with silvopasture throughout the study period, as evidenced by participation in silvopasture events and by comments in our interviews.

Some farmers showed increasing confidence in silvopasture over the study period, while others expressed more concern about the labor and management needed. For example, in northwestern Wisconsin in 2015 a farmer who had recently converted some woods to silvopasture spoke primarily about the challenges of converting and expressed concerns about how the trees would hold up to livestock impact. In the focus group conducted 32 months later, that farmer was confident about his ability to manage silvopasture (which he often referred to as savanna) and enthusiastic about its benefits for his livestock:

...my [open] pastures always go into dormancy July and August, pretty much. And the savanna pastures do not because of the trees. And while it's not great tonnage, it's of great value because they still have grass when they normally wouldn't... And now that I've done that, what I value even more is it creates a tremendous amount of diversity in the animal's diet. And I'm absolutely convinced my animals do better than others, not because of genetics, but because of that diversity in their diet. And I really value my savannas because of that. The trees grow faster. We have a lot more game than you normally would, if you're into hunting and that kind of thing... And if I had to sell land, I'd sell my pastures before I'd sell my savannas.

The grazing network in northwestern Wisconsin included two agricultural advisors who actively supported silvopasture, one of whom had worked with this farmer throughout the process of establishing his silvopasture. In 2014 this network included two presentations and a panel discussion about silvopasture in its spring conference. Farmers learned they could talk about silvopasture with their grazing consultant, and during our study period several of

the pasture walks hosted by the network featured silvopasture. In November 2018 the network's conference again featured a silvopasture presentation.

In contrast, in southwestern Wisconsin agricultural advisors who helped coordinate the grazing networks did not promote silvopasture. Farmers in the initial southwestern focus group identified brush management as a major benefit of silvopasture. While they continued to express interest in managing brush, the 2019 farmer focus group in southwestern Wisconsin placed greater emphasis on the limits of using livestock as a site management tool and on the limits of current silvopasture knowledge. For example, one farmer in the 2019 focus group had cleared an area of woodland for silvopasture. He spoke about how nice it was to regain access to the old oak savanna that had become impassable due to dense understory growth during the years when livestock were excluded. But later in the conversation he added:

We have problems with black locust, and seeing all those runners pop up, it's just a carpet. ... I think [the cattle] get some of those initial sprouts, but it's more of a supplement. With the kind of management system [we use], they're not going wild on it. I do notice they'll get those young, tender sprouts. But if it gets beyond that maybe they'll take a nip of a couple leaves. That's typically what I observe with cattle.

This statement reflected a broader discussion about the challenge of getting sufficient livestock browsing and physical impact to control weedy shrubs and trees without damaging soils or desirable trees. In this same focus group, the farmers discussed the superior ability of goats to browse shrubs but also noted that, like all livestock, goats do not spare the species that a land manager might want to keep. The group also discussed the additional labor required to manage and market multiple livestock species. Similarly, farmers in the 2014 focus group in southwestern Wisconsin spoke of silvopasture as a tool to restore savanna habitat, while farmers in the 2019 focus group in the same region discussed the difficulties and limitations of using livestock for ecological site management such as savanna restoration.

Still, although there was much discussion of the challenges of using grazing to manage the shrub understory, most of the focus group participants felt that livestock could help in some situations. The site with black locust referenced above was part of a silvopasture establishment trial, and in areas planted with improved forages, it was noted that black locust resprouting was much less of a problem compared both to areas that weren't planted and areas that were planted but not grazed. Another farmer, who was quite skeptical of silvopasture, commented.

We had a watershed meeting here last month and one of the members ... fenced off his woods. ... Now it's five years [later] and it's grown up with all this stuff he doesn't want. So he's kind of, 'what do you do, how do you win, or do you have to just be patient and you have to wait fifty, a hundred years for nature to kindly kill this stuff off on its own' or what.

As another respondent said of silvopasture as a strategy to manage brush, "It's not a silver bullet by any means, but it's certainly I think moving in the right direction."

One concern mentioned in a 2018 northwestern focus group was the worry that the growing acceptance of silvopasture could be set back by one bad example:

And then also I'm beginning to wonder about we can make all this progress and ... we're bound to find somebody who's going to do this all wrong. And it's going to be on a major highway and everybody's going to see it where there are 5,000 animals on 10 acres and the hillside comes down and all the trees die. So we need some research to say, "Well, based upon the research, you should never have been doing that or been allowed to do it. And that's why this all happened." It's not the concept. It's the execution of it that was wrong.

This quote illustrates the sense that this loose group of farmers and resource professionals is making progress by working together, as well as their awareness that the approach of integrating grazing with trees still needs to develop clearer guidance, and that research will play an important role in developing that guidance.

3.1.1.3. Contextual factors and economic viability of silvopasture

Farmer comments indicated some regional differences in the economics of converting woodland to silvopasture between the southwestern and northwestern focus groups. In Wisconsin, property tax assessment categories result in lower tax levies on wooded pasture than on ungrazed forest land (not enrolled in state forestry tax incentive programs), and in both regions property taxes were cited as an economic incentive to let livestock graze woodlands. Farmers in both regions saw silvopasture as a way to access those tax benefits without causing the environmental damage associated with unmanaged livestock access to woodlands.

However, in northwestern Wisconsin, where paper mills provide a market for trees that are not timber quality, several farmers mentioned income from commercial thinnings of their woodlands to establish silvopasture. In southwestern Wisconsin the market for wood is limited to high quality sawtimber, and none of the farmers in that area spoke about income from thinning their woods to establish silvopasture.

3.1.2. Resource professionals' perceptions and knowledge

Among resource professionals (i.e., agricultural advisors and foresters) we observed some individuals whose support for silvopasture increased over the course of the study period; we did not observe any individuals who decreased their support. In earlier interviews the agricultural advisors were all open to the idea that silvopasture could play a positive role in Wisconsin grazing farms, and several mentioned examples of farmers who were already experimenting with silvopasture. However, except for one professional in northwestern Wisconsin, they did not talk about providing silvopasture advice in the course of their work. In contrast, in the later interviews several agricultural advisors spoke about incorporating management of paddocks with trees in grazing plans or other advice to farmers:

I usually look at the trees and the cover, see if it's a heavy cover, that might be something we maybe stay out of or just go into during the hot periods for just shade. And if it's a mixed cover with quite a bit of open area, then that might be a separate area for late summer grazing when it's hot.

In 2014, that advisor had said “We were asked to do a presentation on grazing in the woods And we denied it. We didn't want to get into that” (Mayerfeld et al., 2016). In 2019, when asked if incorporating areas with trees was standard practice for grazing specialists, the advisor said, “Right now we're working on that because they usually just see woods, and they just line them out [of the grazing plan].” While this statement shows that many agricultural advisors still were not comfortable providing silvopasture advice, it also indicates that it had become acceptable to promote silvopasture as an agricultural practice to professional colleagues, which was not the case 5 years earlier.

Foresters did not report giving silvopasture management advice but indicated that the opposition to any integration of livestock with trees was softening over time. In a 2019 interview a forester commented that forestry guidance to farmers with woodlands used to be “Don't burn, don't graze and just let it go.” He went on to say

And now what do we do? We tell people, ‘Burning's not so bad. And actually it's fantastic,’ and, ‘Oh, you might want to think about grazing.’ So it's like, okay. We've come a long ways on that.

We also found that foresters in our focus groups varied widely in their attitudes toward silvopasture. At the beginning of this project, we were warned that most foresters were likely to strongly oppose any integration of livestock and trees. In our direct interactions we found that foresters were indeed strongly critical of poorly managed woodland grazing, but most were open to considering how silvopasture management might improve environmental outcomes, at least in some settings. As one forester commented,

Certain agricultural producers out there are going to graze the woodlands, and that's just economics. It's going to happen. So, we should look for those opportunities that we can decrease the environmental impact based on that.

Tentative acceptance of silvopasture was evident both in mixed focus groups that included agricultural advisors as well as foresters, and in a focus group with all foresters. Several expressed particular interest in the potential for goats to manage invasive species.

Like the interviews, workshop, pasture walk, and conference evaluation results suggest that foresters' attitudes toward silvopasture are variable (Figure 2). Nearly half of respondents did not know what their local foresters' attitudes were, but the other respondents reported that forester attitudes toward silvopasture were roughly evenly split between supportive and unsupportive, with many perceived as neutral. Evaluation respondents were primarily farmers but also included a few resource professionals.

Resource professionals' comments about silvopasture were influenced by changes in broader contexts impacting farms and surrounding communities. Two years before our initial focus

group the region had experienced severe drought and extreme heat, while the summers of 2017 and 2018 were relatively cool and wet, and 2018 included extreme precipitation events and flooding. The later focus groups placed less emphasis on the value of trees for shade and woodlands for emergency source of forage, and more emphasis on how silvopasture might handle extreme precipitation. Similarly, shifts in the farm economy were reflected in the discussion. In 2014, when commodity crop prices were high, resource professionals thought silvopasture management might improve environmental outcomes when conversion of pasture to row crop cultivation led to more woodland being converted to pasture. In 2019 resource professionals discussed the increased interest in alternative crops and land management systems such as silvopasture, given depressed crop prices.

The agriculture economy right now, it's especially bad for dairy farmers, but nobody is making very much money right now. This is the first time I've ever heard discussion among dairy farmers about diversifying. ... They're thinking they need to reduce their risk by adding other crops and other sources of income, and trees might be [one of those alternatives].

Although the specific issues changed over time, the discussion among farmers, as well as resource professionals, often highlighted how attitudes toward silvopasture interacted with regional resource and socio-economic issues.

3.1.3. Complexity and uncertainty in perceptions of silvopasture

3.1.3.1. Knowledge limitations

Even though the taboo around discussing the integration of livestock and trees has weakened in our study area, the nature of silvopasture raises challenges for resource professionals who want to offer clear, research-based, financially-sound advice. Silvopasture entails a complex set of principles and practices drawn from both forestry and agricultural science, with context-dependent applications, making universal management prescriptions difficult to develop and deliver. As one forester commented when a focus group was discussing the potential for silvopasture to help with oak regeneration,

I think there are so many variances that could go about this. The type of cattle. If it's beef, dairy cattle, sheep, goats, whatever. There's so many variances in that. The tree species you're wanting to regenerate. The time of year. It seems like a whirlwind of a headache that you're trying to put together.

Furthermore, there are substantial limitations in the fundamental knowledge base, including a lack of regional research. Both natural resource professionals and farmers questioned the applicability of silvopasture research on southern pine plantations to the mixed hardwoods of the upper Midwest:

I'd like to see some controlled experiments in the northern forest rather than just from the southern United States where we could show an impact on the accumulation of forest product.

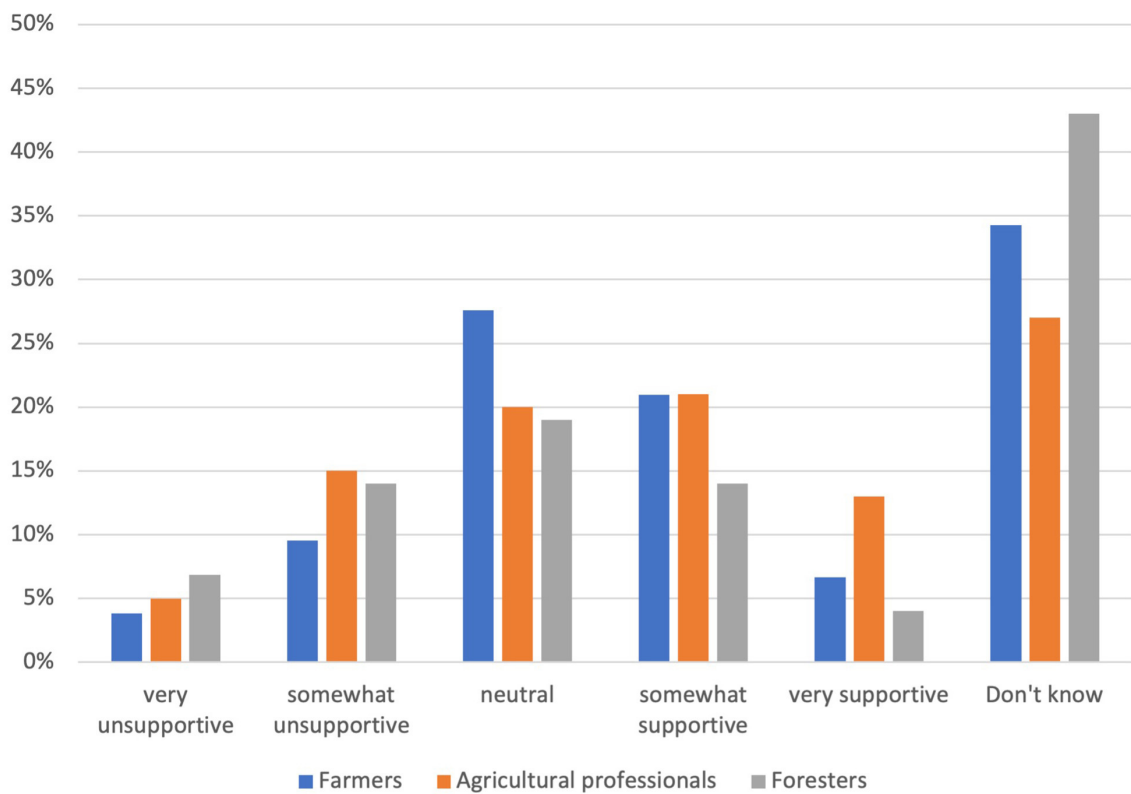


FIGURE 2 Aggregated end of program workshop evaluation responses, 2014–2019, in Wisconsin and Minnesota, USA, to the question “Thinking about the past year, how supportive or unsupportive are professionals and farmers in your county toward silvopasture?” *N* = 107.

This comment was followed by a discussion of the differences between southern pine plantations and diverse northern hardwoods, including slower growth of northern trees, and concluded with the observation that “it might take two generations of scientists to get an answer.”

3.1.3.2. Uncertainty about silvopasture policies and financial support

In the early focus groups, there was only one mention of the possibility of financial support from public agencies for silvopasture. Most of the later interviews, however, included discussion of the possibility of Natural Resources Conservation Service (NRCS) support for silvopasture. This type of financial assistance (provided through NRCS from the US Department of Agriculture) can be an important aspect of silvopasture economics since establishment costs can be substantial, but the interviews reflected considerable uncertainty. NRCS provides financial assistance for rotational grazing but traditionally has strongly discouraged grazing of woodlands. There were some efforts to have NRCS in Wisconsin and some surrounding states provide financial assistance for silvopasture establishment by planting trees, but the reimbursement rates were low, farmers often did not realize they could ask for this assistance, and most agricultural advisors were uncertain about the current policies for silvopasture assistance, as this exchange among resource professionals illustrates:

“And, if we start thinking about silvopasture agroforestry, is that a cost share practice at all? For NRCS?”

“Not right now.”

“So now it would be 100% on the landowner to, again, how long before they start generating revenue or income from that?”

“Well, wait a minute – for planting we don’t call it silvopasture, we call it tree planting. So if you want to plant trees in the pasture, we do cost share that.... There’s also biological brush management... So there’s other practices. We don’t call them silvopasture.”

Another agricultural advisor (and farmer) in a different 2019 interview commented:

And then, with the new EQIP which I work with for cost-sharing with fence or for fencing and watering [for managed grazing], it’s like they are more into promoting converting tillable ground or work ground that can be pasture. When I first started, if you could prove or show there was history of grazing at one time then they would cost share to put the fencing in. But now, if it’s got trees on it, they won’t cost share at all. So that’s actually going to probably blow up your silvopasture part of it to some extent, too.

Over the past 2 years Wisconsin’s NRCS has been working with the Savanna Institute to add financial and technical assistance for planting trees to establish silvopasture, but most farmers and

agricultural professionals, including county NRCS staff, are still uncertain about these policies.

In 2014, resource professionals spoke in general terms about the need for more information on the economics of silvopasture. In the 2019 interview, resource professionals in the southwestern part of the state devoted considerable discussion to the need for better markets for a variety of tree products, from lower quality wood to nuts, in order to increase the economic viability of silvopasture. This focus on markets and financial assistance in later interviews reflects a shift to thinking about silvopasture implementation and advice in concrete rather than abstract terms.

Finally, throughout the study period, farmers and resource professionals stressed that Wisconsin property tax policy is an important economic consideration for silvopasture. Resource professionals were frustrated by the fact that the current law provides a tax break for any pastured woodland, regardless of management and environmental outcomes, and farmers spoke about considerable variation in how local tax assessors interpret the rules. In the November 2018 focus group, one farmer described discussing silvopasture with the assessor:

“We pay much more real-estate taxes on woodland than on cropland, and so last spring, I invited our assessor to come out to the farm. And he was knowledgeable of silvopasture but hadn’t seen any of it, and he didn’t want to go out with me. We sat down and looked at our maps, and he wanted me to show him where I had hardware... He lowered our valuation—I don’t remember how much—quite a bit on those acres.”

“So he accepted your explanation?”

“Yup.”

“And seemed to be knowledgeable enough to adjust for that?”

“Yup. He’s heard about it, but he just...”

“You were the first person he’d talked to specifically about it.”

“Yeah, well, we’re probably the only rotational grazers in our area.”

3.2. How did coverage of silvopasture change between 2009 and 2019 in a popular grazing publication?

To supplement the interviews we searched all issues of a long-established grazing periodical to understand how perceptions of silvopasture were evolving over time. This analysis revealed an increase in attention to silvopasture over the past decade, as well as a growing appreciation generally of trees as assets to pasture-based livestock systems. [Figure 3](#) summarizes the number of times our search terms appeared in *Graze* in a grazing management context in articles and announcements.

From 2009 until late in 2013 the term “silv[opasture]” was never used in the publication. In November 2013 the term appeared for the first time in an announcement of a combined silvopasture and grazing conference. Then in 2014 *Graze* featured three articles about silvopasture by farmer and writer Tracy Frisch, and the word appeared more than 60 times. In 2015 and 2016 there were no silvopasture articles, and the word only appeared once each year, but in 2017 the word appeared 31 times. In 2018 the word silvopasture

appeared 86 times, with articles about silvopasture by forester and farmer Bret Chedzoy and agroforestry researcher Joe Orefice in five different issues. In the first 6 months of 2019 the word appeared eight times – four times in articles that were not explicitly about silvopasture and the other four times in an article about living barns by Brett Chedzoy, a silvopasture advocate from New York state. However, although the word “silvopasture” does not appear until 2013, many articles both before and after that date refer to the use of trees in pasture systems.

In 2009, 2013, and 2017, *Graze* included a feature where five experienced graziers from different states responded to the question “How do you manage heat stress?” In each of those years use of shade from trees was one of the most common strategies cited in the answers, but there is a progression over that time from barely mentioning shade to discussing shade management in some detail.

For example, in the 2009 *Graze* feature on managing heat stress only one of the farmer columnists listed use of shade as a main strategy, and all mentions of shade were quite brief, like this quote from a Minnesota farmer:

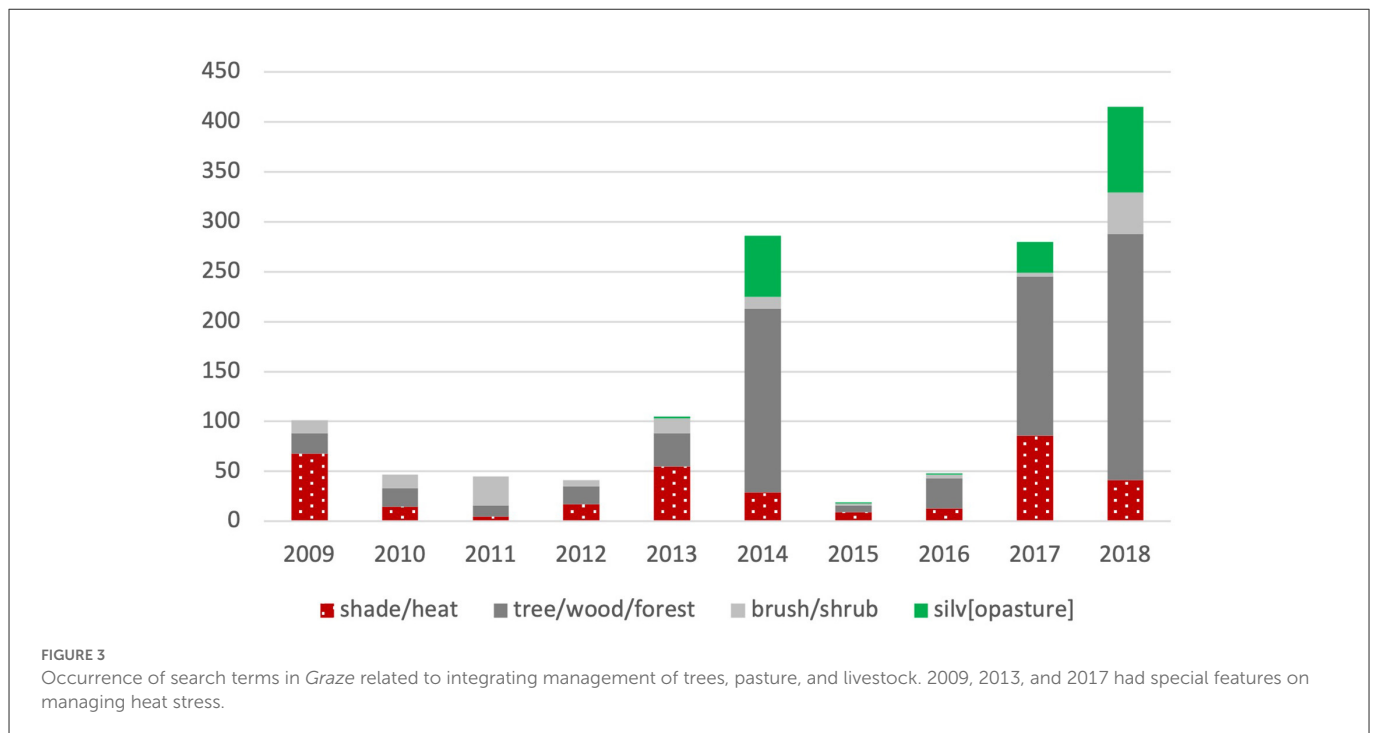
If the heat gets real bad, we use our few shaded paddocks, putting the cows there for a few hours in the middle of the day. We try to use these paddocks sparingly to avoid creating mud pits ([Mroczenski et al., 2009](#)).

In 2013, when *Graze* next ran the heat stress feature, three of the five farmers discussed shade management as a primary strategy for dealing with heat stress in their columns, and two of those responses devoted several paragraphs to describing how they manage the use of their shaded paddocks. Here is the final paragraph from one of those responses:

We re-fenced a few of the milk cow areas last year to get more trees in some paddocks. We use those paddocks in the day and then go to the shadeless paddocks at night. There are times when if we see a hot spell being forecast, we’ll alter the rotation if we can to make sure the cows have the shade paddocks in the day. If the timing for that doesn’t work and it’s too hot for the cows, we’ll bring them in the barn in the afternoon until they can go back out. We have been thinking of planting some trees in all the paddocks so that in the future everyone can just stay in their paddocks ([O’Neill et al., 2013](#)).

In the 2017 *Graze* heat stress feature, all five farmer columnists discussed using shaded paddocks to manage heat stress, and four of those responses listed access to tree shade as a primary strategy. Those four farmer-advisors each devoted several paragraphs to describing how they manage the use of their shade paddocks, including reserving shaded paddocks for hot weather, timing access to shade for daytime and access to unshaded pastures at night, and need for frequent rotation ([Sheffer et al., 2017](#)).

After using trees for shade, the most common positive mention of trees in grazing systems was to provide shelter in winter. Often, articles also mentioned trees and/or shrubs as causing problems (e.g., excess manure accumulation, shelter for predators, or damage to fences) or as something to remove in order to create new pasture. [Figure 4](#) groups search term appearances from 2009 to 2013 and from 2014 to mid-2019, not including the articles about managing heat stress or the articles about silvopasture. Even excluding the articles



on silvopasture, trees are more often characterized as an asset to the grazing system after 2013 than before. The reporting on silvopasture and the role of trees in grazing systems reflects increased interest in the practice at the same time that it transmits knowledge.

4. Discussion

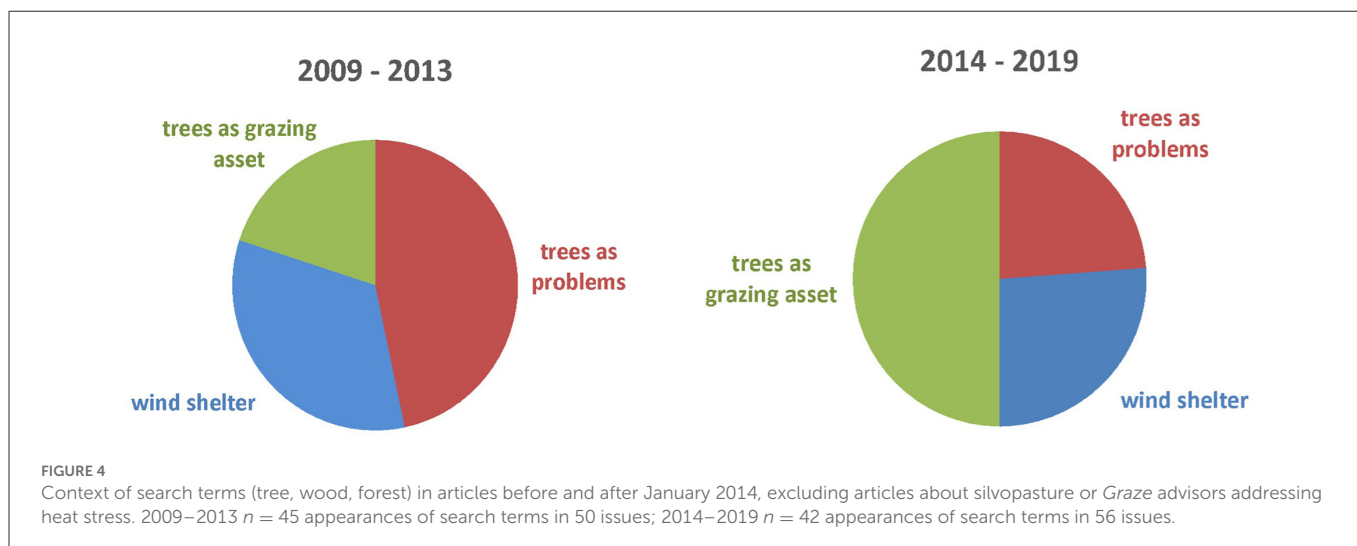
The resource professionals interviewed for this study agreed that conversion of grazed woodlands and some annual row crop fields to silvopasture would likely improve environmental outcomes for those sites (see also Brantly, 2014). One important barrier to adoption of silvopasture is that the majority of livestock farms do not practice rotational stocking, a necessary management tool for silvopasture in the Midwest. As Figure 1 shows, in 2017 only 6,786 farms (20% of the 34,400 farms with pasture) reported practicing rotational grazing in Wisconsin, and only 1,120 farms reported practicing any kind of agroforestry (including but not limited to silvopasture). Nationally 265,162 farms (21% of the 1,236,980 farms with pasture) reported practicing rotational grazing, and only 30,853 practiced any kind of agroforestry. Both in Wisconsin and regionally, farms that already practice rotational stocking constitute the likely pool of potential silvopasture adopters in the near term. Our findings describe how silvopasture is perceived by these potential adopters and identify some of the contexts fostering and limiting the application of silvopasture in this region.

In the absence of a robust history of silvopasture research in this region, those farmers who want to implement silvopasture must act simultaneously as managers and informal researchers, observing conditions on the farm and results of previous management and adjusting their actions accordingly. To support farmers in silvopasture adoption, agricultural researchers and advisors can facilitate farmer-to-farmer knowledge exchange and help identify underlying agroecological principles that guide, but do not dictate,

management (Röling and Jiggins, 1998; Poncet et al., 2010; Lyon et al., 2011). In northwestern Wisconsin, where several agricultural advisors embraced that role and explicitly invited knowledge exchange about silvopasture, we observed good communication among farmers about their experience and a clear increase in support for the practice in the grazing community. In southwestern Wisconsin, which also had an active grazing network but lacked an embedded facilitator of silvopasture knowledge exchange, farmers remained interested in silvopasture but cautious about its challenges and feasibility.

Our interviews reflect the inherent complexity of practicing silvopasture, as well as a dearth of regional research. Many researchers have observed that complex agroecological innovations require a shift from a technology-transfer paradigm of advisors delivering prescriptive direction to a systems-based paradigm of advisors facilitating farmer-led innovation and knowledge exchange (Röling, 2009; Lyon et al., 2011; Provenza et al., 2013; Blesh and Wolf, 2014; Ingram, 2015). When farmers and resource professionals in our study emphasized the need for local research and demonstration, they were implicitly recognizing limits to geographic scalability and the reality that a practice that is sustainable in one location may have different impacts when transferred to other biophysical and socioeconomic settings (Wigboldus et al., 2016).

Individual knowledge and social support (e.g., an active community of practice) are important, but contextual factors (e.g., a local market for pulp-grade wood) also factor crucially into the viability of the innovation (Loorbach et al., 2017). This dynamic, wherein grassroots-level actors' knowledge, agency, and coordination are constrained or supported by contextual factors, is often analyzed in sustainability literature with what is called a multilevel perspective (Geels, 2002, 2011; Klerkx et al., 2010; Elzen et al., 2011; Ingram, 2015; Wigboldus et al., 2016). In our case, a multilevel perspective offers a heuristic for how contextual factors (including markets, research and extension practices, tax policy and agency support,



cost and availability of labor, and other land uses), interact with individual knowledge and social support to influence the viability of silvopasture. For instance, in northwestern Wisconsin, the grazing network and its embedded facilitators of silvopasture knowledge-exchange, as well as the pulp market, were important factors in how the viability of silvopasture was perceived compared to southwestern Wisconsin.

Silvopasture, like all agroforestry practices, brings an added temporal challenge. Farmers managing forages and livestock on a 1 to 3-year basis for short term revenue must simultaneously manage for trees with a growth period from multiple decades to over a century. The uncertainty of long-term outcomes in silvopasture poses challenges for farmers and researchers (Arbuckle, 2009). We suspect that this uncertainty helps explain why most agricultural advisors still do not promote silvopasture, even though the taboo around integrating livestock with trees weakened over the course of the study. Methodologies to manage under conditions of uncertainty in long-lived complex systems, such as adaptive resource management, are well developed in forestry, grazing, and conservation literatures (Gregory et al., 2006; Teague et al., 2013). Despite its limitations (Gregory et al., 2006; Doremus, 2011; Rissman and Wardropper, 2021), adaptive management may offer a useful framework for resource professionals and farmers to develop working silvopasture systems in novel environments such as the mixed hardwoods of Wisconsin. Participatory research approaches offer additional models for combining place-based and long-term farmer insights with academic research to address complex agroecosystem management challenges (Hoffmann et al., 2007; Cerf, 2011; Snapp et al., 2019). Grazing networks, with their history of peer-to-peer knowledge exchange and their promotion of adaptive rather than prescriptive management, offer an appropriate starting point for co-creation of silvopasture knowledge in this context of complexity and limited local research (Paine et al., 2000; Lyon et al., 2011; Nelson et al., 2014; DeDecker et al., 2022).

Confusion around financial assistance and property tax policy added another barrier to silvopasture adoption during our study. At the end of our study period, the Natural Resources Conservation Service in both Wisconsin and Minnesota began working on clarifying state standards for financial assistance for silvopasture

establishment and management, and this work continues as of this writing (Hart, 2019; Braun, 2022). These policy efforts represent a significant step forward in making silvopasture accessible for farmers, and also reflect the change in attitudes toward silvopasture that has occurred in the region.

5. Conclusion

Silvopasture in the US Midwest remains an uncertain proposition for most farmers and natural resource professionals, due in part to the history of woodland degradation by poor livestock management, and in part to the inherent complexity of the practice. Whereas, prior to 2014 there was little research and education about silvopasture in the Midwest, more marked interest in silvopasture emerged and persisted in and around Wisconsin from 2014 to 2019. Of the two regions we studied, the enthusiasm, knowledge, and practice of silvopasture grew in northwest Wisconsin, which coincided with the development of a community of practice that included farmers and agricultural advisors cooperating in a favorable set of landscape and market circumstances. In contrast, farmers remained more cautious about the practicality of silvopasture in southwest Wisconsin where markets were less favorable and farmer adopters and professional advocates did not coalesce into a silvopasture community of practice.

We also observed changes in attitudes among agricultural advisors and foresters: early in the study period most of these resource professionals did not discuss silvopasture in public, but later in the study period some agricultural advisors gave silvopasture advice, and some foresters' attitudes reflected increasing openness to silvopasture in certain situations. Overall, the findings from this study suggest that (1) contextual factors such as climate, landscape attributes, markets, and existing land uses influence stakeholders' attitudes about silvopasture, and (2) positive attitudes and knowledge about silvopasture can be cultivated in local communities of practice that exchange information about management strategies appropriate to the complex, long-term, and context-dependent nature of the practice.

The diversity of potential silvopasture composition and design options in this region coupled with the time required

to study trees means that standard agricultural research and extension approaches are insufficient to support farmers practicing silvopasture. Rather, farmers, resource professionals, and researchers need to collaborate over the long term. This process of collaboration can begin using general principles derived from silvopasture, forestry, and grazing research and experience, but it must adaptively adjust those principles based both on formal measurements and on farmer observations. Because other continuous living cover systems also add temporal and species complexity, similar collaborative and adaptive approaches may be needed across the board to transform our agricultural monocultures to sustainable agroecosystems.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of Wisconsin-Madison Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

DM and KK conducted the data collection and analysis and drafted the article. All authors contributed

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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