Agroforest Syst
https://doi.org/10.1007/s10457-021-00665-z

Thinning forests or planting fields? Producer preferences for establishing silvopasture

Philadelphia Wilkens · John F. Munsell · John H. Fike · Gabriel J. Pent · Gregory E. Frey · Benjamin J. Addlestone · Adam K. Downing

Received: 12 January 2021 / Accepted: 20 July 2021

Abstract Silvopasture is the intentional integration of trees, forages, and livestock. Benefits of this agroforestry practice include shade for livestock, nutritious forage, and reduced wind speed in pastures, as well as ecosystem services and tree products. The literature indicate that some livestock producers are interested in silvopasture, but little is known about their establishment preferences and if they vary by demographics or operation type. This study hypothesized that producers are equally interested in planting trees in pastures (planting) and reducing forest canopy and planting forages (thinning) to establish silvopasture, and that the effects of the potential benefits of silvopasture on their preferences are similar. To test these hypotheses, 307 livestock producers in Virginia, United States of America were surveyed about whether they prefer planting or thinning. Producers also were asked about the extent to which potential benefits of silvopasture affect their preferences. Nearly 25% of the 139 respondents (response rate = 45%) were 'very interested' in thinning, compared to 8% for planting. Animal performance and welfare was their primary goal, but forest management and whole-farm productivity also were important. Guidelines are needed for maintaining stand health and productivity when thinning and for improving tree protection and growth in pastures when planting to establish silvopasture.

Keywords Adoption · Forest management · Tree planting · Livestock

P. Wilkens
U.S. Endowment for Forestry and Communities, Greenville, SC, USA

J. F. Munsell (✉) · J. H. Fike · G. J. Pent · B. J. Addlestone
Virginia Tech University, Blacksburg, VA, USA
e-mail: jfmunsel@vt.edu

G. E. Frey
United States Forest Service, Research Triangle, NC, USA

A. K. Downing
Virginia Cooperative Extension, Madison, VA, USA

Introduction

Silvopasture is an agroforestry practice defined as the intentional integration and co-management of trees, forages, and livestock (Orefice and Carroll 2017). Benefits include shade for animals, reduced wind speed, nutritious forages, timber and non-timber tree products, and ecosystem services such as increased biodiversity and carbon sequestration (Kurtz 2000; Workman et al. 2003; Montagnini and Nair 2004; Shrestha and Alavalapati 2004; Buergler et al. 2005; Moorhead and Dickens 2012; Pent et al. 2020a). There

Published online: 04 September 2021

are two general silvopasture establishment methods. One entails planting and managing trees at low densities in various configurations in pasture (*planting*), and the other involves thinning a portion of forest canopy to allow sufficient light penetration, followed by planting forages (*thinning*).

Important considerations when planting include tree species, stem density and thinning, site preparation, planting configuration (i.e., rows, clusters, contour), livestock rotation, and measures such as fencing and tree tubes that protect seedlings and saplings from potential animal damage and browse (Fike et al. 2004; Hamilton 2008; Karki 2015). Important considerations when thinning include cutting intensity, maintenance, frequency, and timing, along with residual species and growing stock quantity and quality, suitable forage mixtures, forage cultivation, and overall stand health and productivity (Walter 2011; Fike et al. 2017). Livestock are managed in both methods to optimize and maintain the health and productivity of trees and forages.

Montambault and Alavalapati (2005) argue that agroforestry adoption is historically understudied. Existing research generally falls into themes of demographics, land characteristics, and intentions, and results often vary, making agroforestry adoption trends difficult to determine. For example, age correlates with adoption in some studies (Matthews et al. 1993; Strong and Jacobson 2005) and in others it does not (Trozzo et al. 2014a). Sometimes income closely corresponds to producer interests (Featherstone and Goodwin 1993; Cooper and Jacobson 2009) and other times education is significant (Hagan 1996) or it is neutral (Armstrong and Stedman 2012). Property size often relates to intentions (Barbieri and Valdivia 2010; Trozzo et al. 2014b), with potential adoption highest on large farms (Napier et al. 2000), though small holders are known to be interested (Primdahl 1999; Ryan et al. 2003). Land use and land tenure are sometimes found to relate most closely to interest (Armstrong and Stedman 2012; Trozzo et al. 2014a; Mayerfeld et al. 2016). Regardless, producers are generally risk averse because they tend to focus on conventional constraints rather than capitalizing on novel opportunities, which is exacerbated when long-term investments are not a priority or possible (Pannell 1999). Villamor et al. (2014) argue that gender plays a role in land-use decisions, showing women tend to be less likely to take risks, particularly when resources are scarce.

Pattanayak et al. (2003) tender that risk and resource endowments are two drivers of agroforestry adoption because practices involve long-term perennial management amid short-term annual production. Findings in Current et al. (1995), Trozzo et al. (2014b), and Borremans et al. (2016) underscore these challenges and some argue that they can be overcome by experience, extension and technical assistance, and community support. Yet few post-adoption studies exist that help reinforce this assertion (Mercer 2004). Silvopasture research largely focuses on biophysical interactions, animal performance, establishment methods, and production economics (e.g., Buergler et al. 2006; Frey et al. 2017; Pent et al. 2020b). Adoption is not similarly studied. However, several studies report that producers who are interested in agroforestry most often value potential ecosystem services the most (Workman et al. 2003).

In a post-adoption study by Munsell et al. (2018), producers attributed enhanced farm performance to gains in ecosystem services due to the incorporation of trees. The authors report that forest management assistance and agroforestry group membership were essential to producer success. In terms of silvopasture, managing trees to improve conditions for livestock and overall farm health are often higher priorities for producers when compared to economic benefits from timber and non-timber crops (Shrestha et al. 2004). Nonetheless, technical, economic, and marketing information about silvopasture implementation and management with system performance in mind is limited, particularly with respect to forest management when thinning is the method of establishment (Garrett et al. 2004). Moreover, foresters infrequently participate in silvopasture training (Stutzman et al. 2019), which leads to a low rate of technical assistance pertaining to the potential benefits of silvopasture for livestock producers with forestland.

In a small exploratory case study of early silvopasture adopters in North Carolina and Virginia, USA, Frey and Fike (2018) report that producers generally favored thinning over planting. The authors note that although planting may generate economic benefits in the long term, thinning is more sensible in the short-term because it generates revenue, increases pasture, and may improve stand conditions and overall land health and productivity. Planting trees into existing

pasture also requires that producers effectively commit to their tree investment (Frey et al. 2013). Thinning begins from the opposite end of the paradigm and moves producers in the direction of increased pasture, but it retains forest cover and the associated products and services.

This study seeks to contribute to silvopasture adoption literature by determining whether livestock producers prefer to establish silvopasture by thinning existing forest canopy (thinning) or by planting trees into pastureland (planting). To accomplish this objective, livestock producers in Virginia, USA were surveyed about establishment preferences. They also were queried about the extent to which particular benefits (e.g., livestock productivity, timber profitability) influence their interest in establishing silvopasture using thinning or planting, and were asked to report demographic and operational information. Hypotheses were that there is no difference between producer preferences for planting and thinning, and that the effects of potential benefits on their preferences are the same. Producers also were asked to provide open-ended comments regarding perspectives and rationale pertaining to both methods of establishment. Findings from the study highlight important insights for the forestry community regarding livestock producer preferences and needs for silvopasture establishment.

Methods

A comprehensive livestock producer registry does not exist in Virginia, USA. Enrollees in United States Department of Agriculture (USDA) livestock limitation cost-share programs in the state constitute a delimited producer population with publicly available contact information. Access to participant names and contact information was approved through the Freedom of Information Act (FOIA) and the Natural Resources Conservation Service (NRCS) advised researchers about livestock-specific cost-share programs to include in the study survey. In total, NRCS recommended cost-share practice codes for Fencing, Access Control, Brush Management, Prescribed Grazing, Silvopasture, Windbreak/Shelterbelt Establishment, and Tree/Shrub Establishment. They provided program enrollment information for the practice codes for the years 2014–2017. Three-hundred and seven livestock producers were surveyed using the resulting registry for this study and an analysis of the association between silvopasture interest and type and nature of operations is reported in Wilkens et al. (2021).

The livestock producer survey was designed based on agroforestry and technology adoption literature, including environmental, economic, and resource-related findings (Pattanayak et al. 2003; Venkatesh et al. 2003; Trozzo et al. 2014b). It included quantitative and qualitative sections, and an expert panel of NRCS and other agency and university personnel familiar with livestock producers assisted in developing the instrument. A draft survey was tested using a small pilot study at a statewide livestock producer meeting. During the pilot study, surveys were distributed to producers and NRCS personnel, and each person was given the opportunity to complete the instrument and ask clarifying or substantive questions. Completed surveys were evaluated and written feedback on draft questions was recorded and analyzed. Results were used to prepare a final version for mailing.

The survey process followed Dillman's Tailored Design Method (Dillman et al. 2008). A pre-notification letter informed producers of a forthcoming survey. The survey, a cover letter, and a pre-addressed stamped envelope were mailed ten days later. After 14 days, a reminder postcard was mailed, which was followed by a cover letter, envelope, and replacement survey a week later. The institutional review board number for this research is #18–585, approved under 45 CFR 46.110 categories 5 and 7.

The survey instrument measured operational traits and land use, such as acreage and livestock type, as well as demographic variables (i.e., age, sex, race, income, education) and overall interest in silvopasture and operational variables that were analyzed in a companion manuscript (Wilkens et al. 2021). An established silvopasture system illustration and a short definition of each method (planting, thinning) were included to standardize comprehension (Fig. 1). Producer interest in both silvopasture establishment methods (planting, thinning) were measured using a single Likert-type unipolar ordinal scale (1–5), ranging from 1 = 'I am not interested' to 5 = 'I am very interested'. An annotated arrow above the numerical anchors 1–5 indicated that interest increases from left to right on the response scale. Respondents used open-ended comments to explain their responses, resulting

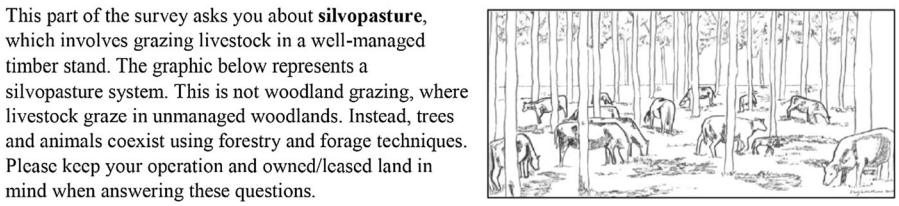

Fig. 1 Silvopasture definition and illustration included in a survey of livestock producers to demonstrate an established system and research reported in Wilkens et al. (2021). (illustration credit: Elizabeth Anderson Moore)

in an accompanying qualitative dataset used to contextualize quantitative analyses.

The survey also measured the extent to which potential benefits increase producer interest in planting and thinning (Table 1). Benefits were based on the nature of the establishment method, expert panel input, pilot test results, and economic, environmental, and resource- and effort-related drivers of agroforestry adoption identified by Pattanayak et al. (2003) and Trozzo et al. (2014a). Single Likert-type ordinal scales (1–4) were used to measure the extent to which each benefit (e.g., shade for livestock) increases producer interest in the associated establishment method (e.g., planting): 1 = Not at all; 2 = A little bit; 3 = A fair amount; and 4 = A lot.

Potential benefits presented to producers formed a livestock-timber-ecosystem performance continuum underpinned by a single technical assistance opportunity specific to the establishment method. Livestock benefits included shade from planting an open pasture, and pasture relief and recovery due to thinning. Timber benefits focused on long-term returns from harvesting planted trees and immediate financial profit from thinning. Ecosystem benefits involved payments for planting trees in an open pasture, and improving forest health and productivity by thinning an existing woodlot. Assistance opportunities included NRCS technical support and cost-share services when planting and forest management and marketing consultation when thinning.

Non-response bias was addressed using the wave method (Rogelberg and Stanton 2007). In this technique, early responses are compared against late responses because late respondents are assumed to be more representative of non-respondents (after Groves et al. 2001) along what is referred to by Filion (1976) as a 'continuum of resistance'. Independent samples t-tests ($\alpha = 0.05$) were used to determine if interest variables differed between late respondents and early respondents. Significant results were not observed.

Wilcoxon-signed rank test ($\alpha = 0.05$) was used to test for differences between producer interests in planting and thinning, as well as differences in the extent to which potential benefits increased their interest. Wilcoxon-signed rank test is a non-parametric procedure that determines if independent paired rank scores differ significantly. A reference variable is matched against a paired comparative variable for a single observation. Outcomes are scored as negative, positive, or neutral. Negative scores occur when a reference variable exceeds the paired comparative.

Table 1 Benefits associated with two forms of silvopasture establishment (planting, thinning) included in a survey of livestock producers

Benefits associated with planting	Benefits associated with thinning
Shade for livestock	Forest health and productivity
Ecosystem markets payments	Profit from thinning
Long-term timber returns	Pasture relief and recovery
NRCS agent assistance	Forester assistance

Each benefit was accompanied by a scale (1–4) that respondents used to indicate the extent to which the benefit increases their interest in planting or thinning to establish silvopasture

Scale 1–4 was as follows: 1 = Not at all; 2 = A little bit; 3 = A fair amount; and 4 = A lot

Positive scores occur when a comparative variable surpasses the reference. A neutral score indicates no difference (Wilcoxon 1945).

Response frequencies were evaluated to study the distribution of producer interests in planting and thinning, and the range of effects that potential benefits have on their position. Operational characteristics, ownership traits, and demographics were evaluated in terms of frequencies and percent to describe the respondents. Mean scores for the two preference items (planting, thinning) were factored by demographic and operational categories to depict central tendencies in response across the range of respondent characteristics. A one-way ANOVA test ($\alpha = 0.05$) was used to determine if the amount of forested acreage differs significantly across the level of producer interest in planting and thinning.

Qualitative data were open coded by grouping and labeling similar raw producer comments explaining their responses (Glaser and Strauss 1967). Axial coding was used to group open codes into a final configuration based on thematic similarity (Strauss and Corbin 1990). Data were analyzed using percent frequency and representative comments were selected for presentation in the results. A single researcher conducted all coding and analysis to ensure internal consistency.

Results

One hundred and thirty-nine of the 307 surveys were completed and returned for a response rate of 45.3%. Almost all respondents were males and most were between 45–64 years of age (Table 2). The majority had a bachelor's degree or higher (57.7%) and most household incomes were between $50,000–$99,999 USD (40.2%). Nearly three-quarters of the respondents raised cattle (73.7%), though some worked with sheep, goats, poultry, and other specialty livestock. Livestock production was not a primary occupation for most (63.2%), and the average farm size was 133.5 hectares with 19 hectares in forest. A small percentage (15.1%) reported that their operation did not include forestland. Forested hectares did not differ significantly across interest levels related to planting and thinning ($p = 0.87$).

Mean scores across categorical demographic and operational variables varied slightly. Higher-income producers tended to be more interested in both methods overall, but those making less than $50,000 were more interested in thinning. Though distribution of respondents was highly skewed toward males, it is worth noting that females were slightly more often interested in planting and less so in thinning when compared to males. The average score for those with the least amount of formal education was lowest when compared to other groups regardless of establishment method, and the average was highest for the youngest producers when compared to other groups. Producers of diversified or specialty livestock were more often interested in thinning, and small ruminant producers were more interested in planting.

With respect to the first hypothesis, Wilcoxon signed-rank test results indicated that producers were significantly more interested in establishing silvopasture by thinning an existing forest compared to planting trees in a pasture ($p = 0.001$) (Table 3). Thirty-two producers, or 23.4% of valid responses, were "very interested" in thinning (scale response = 5). If scale responses '4' and '5' are combined, then the number increases to 45, or nearly 33% of the responding producers. Interest in planting differed noticeably, with 11 (8.4%) selecting '5' and 12 (9.2%) selecting '4'.

In terms of the effects of particular benefits on producer interests in planting, creating shade for livestock ($\mu = 2.78$) and access to technical and cost-share assistance ($\mu = 2.82$) were ranked significantly higher than environmental payments ($\mu = 2.55$) and long-term timber profits ($\mu = 2.43$) (Table 4). When it comes to interests in thinning, producers were least moved by profit ($\mu = 2.32$). More important to them were possibilities to improve long-term forest health and productivity ($\mu = 2.74$), provide pasture relief and recovery ($\mu = 2.80$), and have access to forest management assistance ($\mu = 2.82$).

Seventy-seven producers (55%) provided open-ended comments. Shade for livestock was most commonly coded as a reason to plant trees in a pasture ($n = 49$; 64%) (Table 5). Pasture diversification and improving whole-farm health and productivity were also noted ($n = 12$; 16% and $n = 9$; 12%, respectively). Regarding constraints related to planting, references to forfeiting pasture for trees were widespread ($n = 37$; 48%). To a lesser degree ($< 25\%$), producers commented on their concerns regarding tree mortality and management costs, as well as site quality

Table 2 Demographics and ownership characteristics of livestock producer survey respondents. Mean responses to preference questions pertaining to interest in planting and thinning to establish silvopasture are included. Scales were 1–5, with 1 = not interested and 5 = very interested. Mean scores are presented to demonstrate central tendency

Socioeconomic variables	% (n)	μ Planting (1–5)	μ Thinning (1–5)
Age (years)			
25–44	16.3% (22)	2.27	4.23
45–64	51.1% (69)	2.41	3.41
65+	32.6% (44)	2.09	2.92
Gender			
Male	94.8% (128)	2.26	3.32
Female	05.2% (7)	2.50	2.83
Race			
White	98.5% (133)	2.29	3.31
Other	1.5% (2)	1.00	3.00
Education			
Some of or high school degree	27.8% (38)	1.88	3.12
Associates degree	14.6% (20)	2.27	3.67
Bachelor's degree	33.6% (46)	2.52	3.28
Graduate degree	24.0% (33)	2.35	3.31
Income			
Less than $50,000 USD	18.0% (21)	2.22	3.61
$50,000—$99,999 USD	40.2% (47)	2.33	3.13
$100,000-$149,999 USD	23.1% (27)	2.26	3.17
$150,000 and above USD	18.7% (22)	2.45	3.55
Production			
Cattle	73.7% (101)	2.17	3.24
Small ruminants	08.8% (12)	2.60	3.20
Mixed or other	16.1% (24)	2.55	3.59
Primary occupation			
Yes	37.2% (48)	2.26	3.44
No	62.8% (81)	2.25	3.28
Acreage			
Average overall acreage	133.5 hectares		
Average acres of forested land	20.7 hectares		

and operational limitations. Reasons for thinning included a variety of livestock and whole-farm benefits, such as pasture expansion (n = 21; 27%), improved whole-farm management (n = 19; 25%), and shade for livestock (n = 16; 21%). Improving forestland and increasing production and income were also cited (both n = 10; 13%). Common constraints included maintenance requirements (n = 25; 32%), residual tree health and productivity (n = 20; 26%), establishment costs (n = 8; 11%), land suitability (n = 4; 5%), and livestock performance (n = 4; 5%).

In response to opportunities associated with tree planting, one producer noted that they "…would like for my animals to have more shade," and another stated, "My livestock need more shade in summer and shelter throughout the year." A small ruminant farmer said, "Sheep seem to prefer having some trees for shade," and another producer asserted, "Diversity is a benefit to most enterprises. Shade is a weak link in our pastures." Several producers stressed relationships with other goals, with one proclaiming, "We are on a rotational grazing and this would help provide shade and shelter for livestock," and another sharing that "I'm interested in enhancing the pastoral beauty and providing habitat for other animals."

Concern about forfeiting or altering pasture due to planting included comments such as "I have my pastures in fairly good shape. I'm reluctant to tinker

Table 3 Results of a Wilcoxon-signed rank test comparing interest levels in planting or thinning to establish silvopasture

Reference variable	Comparative variable	Rank	N	P
Planting	Thinning	Negative	78	.001*
		Positive	24	
		Neutral	37	
Frequency n (%)				Frequency n (%)
1 = 47 (35.9%)				1 = 11 (09.2%)
2 = 30 (21.9%)				2 = 21 (17.5%)
3 = 31 (22.7%)				3 = 43 (35.8%)
4 = 12 (09.2%)				4 = 13 (09.5%)
5 = 11 (08.4%)				5 = 32 (23.4%)

Frequencies are the number of livestock producers that responded using survey scale options 1–5 (1 = not interested and 5 = very interested)

Positive ranks are the number of times the reference variable (planting pasture to establish silvopasture) exceeds the comparative variable (thinning forests to establish silvopasture). Ties are neutral

*Significant ($\alpha = 0.05$)

Table 4 Wilcoxon-signed rank test comparing the effects of specific benefits on livestock producer interest in establishing silvopasture by planting trees in pasture or thinning a percentage of a forest canopy and planting forage

Method	Reference variable (mean, 1–4)	Comparative variable (mean, 1–4)	n	P
Planting	Shade for livestock (2.78)	Ecosystem Payments (2.55)	122	0.01[a]
		Long-term timber returns (2.43)	120	0.00[a]
		NRCS assistance (2.82)	120	0.69[c]
	Ecosystem Payments (2.55)	Long-term timber returns (2.43)	116	0.36[c]
		NRCS assistance (2.82)	118	0.00[b]
	Long-term timber returns (2.43)	NRCS assistance (2.82)	116	0.00[b]
Thinning	Forest health and productivity (2.74)	Profit from thinning (2.32)	108	0.00[a]
		Pasture relief and recovery (2.80)	105	0.26[c]
		Forester assistance (2.82)	107	0.36[c]
	Profit from thinning (2.32)	Pasture relief and recovery (2.80)	107	0.00[b]
		Forester assistance (2.82)	107	0.00[b]
	Pasture relief and recovery (2.80)	Forester assistance (2.82	107	0.89[c]

Means represent the central tendency of livestock producer responses using survey scale options 1–4 (1 = not at all and 5 = a lot)

Positive Rank

Negative Rank

Ties

with them too much," and "It will take land out of production, especially when planting trees until big enough to graze around" reflect producer apprehension. Some were unsure about silvopasture implementation. One example included "I like the concept of silvopasture, but am reluctant to lose production while trees are being established." Other difficulties, such as tree performance and land class were mentioned, with one stating, "I would be more interested if I had more land to spare to get the woodlands started" and another noting that, "Topography is so steep that we have limited pasture already."

Table 5 Coded themes derived from open-ended responses provided by livestock producers (n = 77) in a survey measuring silvopasture establishment preferences

Planting opportunities	% Frequency	Planting constraints	% Frequency
Livestock shading	64	Forfeiting pasture	48
Pasture diversification	16	Costs and time	24
Improved whole-farm health	12	Land class	14
Increase productivity	8	Tree mortality	14
Thinning opportunities	% Frequency	Thinning constraints	% Frequency
Pasture expansion	27	Maintenance requirements	32
Improved whole-farm health	25	Residual tree health	26
Livestock shading	21	Environmental impacts	21
Improving forestland	13	Establishment costs	11
Increasing production and income	13	Land suitability	5
		Livestock performance	5

Themes were identified using open and axial coding, are separated according to two establishment methods: planting trees in a pasture or thinning a percentage of a forest canopy and planting forages. Codes are divided along the lines of opportunities and constraints

In response to thinning opportunities, one producer noted they would be interested in silvopasture, "…if I can increase grazing area and cows. I also think, if managed, it can be good for the woods." Another noted, "It's mutually beneficial to the pasture, trees, and livestock – it just makes sense." Regarding optimizing production streams in a diversified agroforestry system, one producer said "Natural shade for the animals, improved forests by thinning" and a second articulated that benefits include "Clean property, increase production, produce more income." Another example included the following, "I believe in collaborating between forestry and livestock production. I think it is a symbiotic relationship."

With respect to constraints related to thinning, common concerns centered on risk and proof of concept. Example statements included "Cattle in woods will kill trees, which will affect the timber harvest," and "Honestly – it's just another thing to manage at this point. Cattle are not my number one income stream." "High cost for stumping, hard to maintained if not stumped" and "Cost of establishment is not worth the outcome" are also representative of producer apprehension. Some questioned whether integration is possible, noting positions such as "I would need to be convinced the system works economically and environmentally."

Discussion

Livestock producers' preferences for methods of silvopasture establishment were hypothesized to be the same, but results indicated responding producers were significantly more interested in establishing silvopasture by thinning forest canopies compared to planting pasture ($p = 0.001$). Nearly 25% indicated that they are very interested in thinning as a method to establish silvopasture, whereas only eleven producers (8.4%) reported the same when asked about planting a silvopasture (scale response = 5). Conversely, almost 25% were not interested (scale response = 1 or 2) in thinning and over 50% were not interested in planting. It is probable that some producers without forestland (15.1%) may have responded favorably to thinning if their operation included forestland, thereby increasing the overall rate of interested producers.

Most livestock producers (51.1%) in this study were between the age of 55 and 64, which corresponds to the average producer (59 years) in Virginia (USDA NAAS 2019). Similar to state livestock trends, cattle operations were most common (73.7%), but producers of other ruminants and fowl also responded. The average operation size in this study (133.5 hectares) differed from the state's average of 72.8 hectares. In general, responding producers were well-educated white males with higher-than-average incomes, who

generally manage livestock operations as a second form of income. These results differ to some extent from national trends, but are similar to traits observed in another Virginia NRCS cost-share limitation program study (Commender et al. 2020).

Trends in the average scores across categories were subtle, and demonstrated slight differences in the commonality of responses. Age, income, and education are thought to be related to agroforestry adoption (e.g., Matthew et al. 1993) and older producers generally possess the necessary financial means and land base to do so (Featherstone and Goodwin 1993). In this study, younger producers, those with an associate's degree, and lower income earners tended to be more interested in thinning. Females and small ruminant producers were more interested in planting, but they only account for 5.2% and 8.8% of the responses, respectively. Commender et al. (2020) report that cost-share program participants often are male, older, and in higher socioeconomic brackets, and differ to some extent from the general producer population but that their familiarity with novel management practices makes them a meaningful population for adoption studies. Overall, producers in this study may be more inclined to establish silvopasture when compared to producers that do not participate in cost-share programs, but results demonstrate clear trends when it comes to preferences regardless of demographics and operation type.

Profits from thinning were less compelling to livestock producers in this study when compared to forest health, pasture recovery, and forester assistance, which ranked highest. Results suggest producers are more inclined to establish silvopasture by thinning if doing so improves whole-farm health and productivity, and they are able to work with management professionals who help steward their forests. Previous research indicates that ecosystem services are important aspects of agroforestry, and that challenges include balancing production and conservation with limited information (Workman et al. 2003; Shrestha et al. 2004; Munsell et al. 2018). Access to forester assistance would likely increase the number of producers who are interested in establishing silvopasture, particularly if benefits are demonstrable.

Preference for forester assistance represents an important opportunity. Forestland is used passively by many producers for grazing, but most stands are thought to be under-managed and in poor health. Foresters are best positioned to help livestock producers balance long-term forest health and productivity because silvopasture eschews passive woodland grazing for active stand management (Orefice and Carroll 2017), but Stutzman et al. (2019) found that foresters rarely participate in technical silvopasture training programs, limiting the impact and role of professional forest management. Walter (2011) and Fike et al. (2017) offer some insights about the role of silviculture when thinning to establish silvopasture, yet formal guidelines and recommendations are difficult to find. Development of training for extension foresters would create opportunities to integrate silvopasture technologies into producer forests and pastures. If extension foresters do not know about the principles of silvopasture, then dissemination may be difficult.

Producers in this study preferred thinning to planting, but open pasture conversion was of interest to some. This could lead to new, low-density even-aged forests that require management planning and long-term tending strategies. Preferences for benefits due to planting were similar to those that were interested in thinning. Shade for livestock and technical assistance from an NRCS agent were more compelling when compared to environmental payments and long-term timber profits. Consistent across both methods (thinning, planting) was the importance of ecosystem services, and access to technical service providers that assist with planning, establishment, and management. According to Stutzman et al. (2019), NRCS agents attend silvopasture training programs at higher rates compared to foresters, and are thus more aware and engaged, albeit primarily in terms of planting.

Fike et al. (2004) and others provide recommendations for planting a silvopasture, but with respect to thinning, little can be found that is comparable. In their review of silvopasture literature, including studies on competition, structural dynamics, and system function, Jose and Dollinger (2019) referenced only one publication related to co-management of trees and forages in a thinned system (i.e., Walter 2011). Some foresters may actually favor planting because of its simplicity and lack of management guidelines for thinning, but many of the stands on land used for livestock production may yield profitable sustained yield or, alternatively, may be denuded and in need of rehabilitation and forester expertise. However,

forester training is likely to remain limited in the absence of applied research and demonstration, as well as silvicultural guidelines that balance multiple objectives in a silvopasture. Concern will likely remain among producers and rates of implementation by thinning will be low, or, worse, potentially productive forestland may be cleared for pasture if consultation is difficult to come by.

Qualitative findings point to producer perspectives, where grazing acreage and shade for livestock are increased as a product of thinning to improve forest health and productivity. It was also clear that livestock and whole-farm health are prioritized over timber profit. Financial returns are not something most producers would turn down, but it is unlikely they will act without being confident they can meet the needs of their livestock and operations. Aside from those necessities, costs, long-term management, and suitability were prevalent concerns. Planting must similarly benefit animal and farm conditions, and apprehension about forfeiting pasture for trees was considerable. Other management constraints and unknowns were mentioned, but to a lesser degree. Thus, a greater array of potential constraints was tied to thinning, but none matched the magnitude of the singular concern regarding pasture loss from planting. This is a critical cornerstone of this study and reflects producer priorities for livestock welfare and productivity above all else. It also represents an opportunity for foresters, if they have access to suitable guidelines as well as participate in technical training.

Conclusion

Interests in thinning an existing forest and planting open pasture varied among livestock producers in our study, but the trend toward thinning was distinct. Immediate profit from thinning was not a primary goal among most producers in this study and the potential to limit short-term establishment costs is likely one reason thinning was preferred to planting. More important was improving livestock operations and whole-farm health, including stand productivity. Profit from thinning is a potential benefit, and foresters are in a position to help livestock producers convert their stands while also potentially realizing financial return. Producers noted several concerns about thinning, but their unease was generally outweighed by the thought of losing pasture to plant trees, which many also noted as coming with hazards beyond reducing forages.

Producer interest increased most significantly when technical assistance was possible and farm health and productivity were improved. Access to support from foresters and conservation agents affected producer interest the most, but the former do not attend silvopasture trainings at rates comparable to NRCS personnel and are thus lacking in awareness and comprehension, let alone capability of assisting producers when planting and thinning. Perhaps this is because of the lack of clear guidelines based on silviculture to manage the health and productivity of silvopasture stands. Recommendations including the use of stocking guides, marking techniques, and operational treatments based on science as applied to silvopasture would help fill the knowledge gap with technical support agents.

Producer interests in silvopasture and their preferences for thinning have clear implications for forest management researchers and educators. The potential benefits for forests, farms, and livestock, and the producers, communities, and ecosystems that support them are substantial. Furthermore, the involvement of foresters would help better synchronize agriculture and forestry practices across working landscapes using agroforestry, which could have profound effects on food and fiber supply, economic development, and provision of ecosystem services. Silvopasture is gaining global attention as a sustainable form of livestock production, and the forestry community has a role to play.

References

Armstrong A, Stedman RC (2012) Landowner willingness to implement riparian buffers in transitioning watersheds. Landsc Urb Plan 105(3):211–220. https://doi.org/10.1016/j.landurbplan.2011.12.011

Barbieri C, Valdivia C (2010) Recreational multifunctionality and its implications for agroforestry diffusion. Agrofor Syst 79(1):5–18. https://doi.org/10.1007/s10457-009-9269-z

Borremans L, Reubens B, Van Gils B, Baeyens D, Vandevelde C, Wauters E (2016) A sociopsychological analysis of agroforestry adoption in Flanders: understanding the discrepancy between conceptual opportunities and actual implementation. Agroeco Sustain Food Syst 40(9):1008–1036. https://doi.org/10.1080/21683565.2016.1204643

Buergler AL, Fike JH, Burger JA, Feldhake CR, McKenna JA, Teutsch CD (2005) Botanical composition and forage production in an emulated silvopasture. Agron J 97(4):1141–1147. https://doi.org/10.2134/agronj2004.0308

Buergler AL, Fike JH, Burger JA, Feldhake CM, McKenna JR, Teutsch CD (2006) Forage nutritive value in an emulated silvopasture. Agron J 98(5):1265–1273. https://doi.org/10.2134/agronj2005.0199

Commender KE, Munsell JF, Ares A, Sullivan BJ, Chamberlain JL (2020) The effects of cost-share participant experience on forest buffer retention. Small-Scale for 2020:1–21. https://doi.org/10.1007/s11842-020-09435-8

Cooper ER, Jacobson MG (2009) Establishing conservation easements on forested riparian buffers: opportunities for long-term streamside protection. Small-Scale for 8(3):263–274. https://doi.org/10.1007/s11842-009-9082-6

Current D, Lutz E, Scherr SJ (1995) The costs and benefits of agroforestry to farmers. The World Bank Res Obs 10(2):151–180. https://doi.org/10.1093/wbro/10.2.151

Dillman DA, Smyth JD, Christian LM (2008) Internet, mail and mixed-model surveys: the tailored design method, 3rd edn. Wiley, New York

Featherstone AM, Goodwin BK (1993) Factors influencing a farmer's decision to invest in long term conservation improvements. Land Econ 69(1):67–81. https://doi.org/10.2307/3146279

Fike JH, Buergler AL, Burger JA, Kallenbach RL (2004) Considerations for establishing and managing silvopastures. Graz Land for. https://doi.org/10.1094/FG-2004-1209-01-RV

Fike JH, Downing AK, Munsell JF, Daniel JB, Teustch C, Mercier K, Pent G (2017) Creating silvopastures: some considerations when thinning existing timber stands. VCE-CSES-155P

Filion FL (1976) Exploring and correcting for nonresponse bias using follow-ups of non respondents. Pac Soc Rev 19(3):401–408

Frey GE, Fike JH (2018) Silvopasture Case studies in North Carolina and Virginia. e-Gen. Tech. Rep. SRS-236. Asheville, NC: USDA Forest Service, Southern Research Station. https://doi.org/10.2737/SRSGTR-236

Frey GE, Mercer DE, Cubbage FW, Abt RC (2013) A real options model to assess the role of flexibility in forestry and agroforestry adoption and disadoption in the Lower Mississippi Alluvial Valley. Agric Econ 44(1):73–91. https://doi.org/10.1111/j.1574-0862.2012.00633.x

Frey GE, Fike JH, Downing AK, Comer MM, Mize TA, Teutsch CD (2017) Trees and livestock together: silvopasture research and application for Virginia farms. In: Proceedings of the seventh national small farm conference. September 20–22, 2016, Virginia Beach

Garrett HE, Kerley MS, Ladyman KP, Walter WD, Godsey LD, Van Sambeek JW, Brauer DK (2004) Hardwood silvopasture management in North America. New vistas in agroforestry. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-2424-1_2

Glaser BG, Strauss AL (1967) The discovery of grounded theory: strategies for qualitative research. Routledge, New York

Groves RM, Dillman DA, Eltinge JL, Little RJA (2001) Survey nonresponse. Wiley, New York

Hagan PT (1996) Evaluating determinants of participation in voluntary riparian buffer programs: a case study of Maryland's buffer incentive program. M.S. thesis, University of Maryland

Hamilton J (2008) Silvopasture: establishment and management principles for pine forests in the Southeastern United States. USDA National Agroforestry Center and Natural Resources Conservation Service, Lincoln, USA

Jose S, Dollinger J (2019) Silvopasture: a sustainable livestock production system. Agrofor Syst 93(1):1–9. https://doi.org/10.1007/s10457-019-00366-8

Karki U (2015) Handbook for training field extension and technical assistance personnel sustainable agroforestry practices in the Southeastern United States: training handbook. Tuskegee University, Tuskegee

Kurtz WB (2000) Economics and policy of agroforestry. In: Garrett HE, Rietveld WJ, Fisher RF (eds) North American agroforestry: an integrated science and practice. American Society of Agronomy, Madison, USA, pp 321–360

Matthews S, Pease SM, Gordon AM, Williams PA (1993) Landowner perceptions and the adoption of agroforestry practices in southern Ontario, Canada. Agrofor Syst 21(2):159–168. https://doi.org/10.1007/BF00705227

Mayerfeld D, Rickenbach M, Rissman A (2016) Overcoming history: attitudes of resource professionals and farmers toward silvopasture in southwest Wisconsin. Agrofor Syst 90(5):723–736. https://doi.org/10.1007/s10457-016-9954-7

Mercer DE (2004) Adoption of agroforestry innovations in the tropics: a review. Agrofor Syst 61(1):311–328. https://doi.org/10.1023/B:AGFO.0000029007.85754.70

Montagnini F, Nair PKR (2004) Carbon sequestration: an underexploited environmental benefit of agroforestry systems. Agrofor Syst 61–62:281–295. https://doi.org/10.1007/978-94-017-2424-1_20

Montambault JR, Alavalapati JRR (2005) Socioeconomic research in agroforestry: a decade in review. Agrofor Syst 65(2):151–161. https://doi.org/10.1007/s10457-005-0124-6

Moorhead DJ, Dickens ED (2012) Agroforestry: a profitable land use. an overview of the 12th North American Agroforestry conference. Agrofor Syst 86(3):299–302. https://doi.org/10.1007/s10457-012-9581-x

Munsell JF, Addlestone BJ, Bukowski CJ, Nkembi L, Kingsly N, Moore EA (2018) Relationships between agroforestry and community development according to practitioners. Agrofor Syst 92(5):1387–1396. https://doi.org/10.1007/s10457-017-0084-7

Napier TL, Tucker M, McCarter S (2000) Adoption of conservation production systems in three Midwest watersheds. J Soil Wat Con 55(2):123–134

Orefice JN, Carroll J (2017) Silvopasture – It's not a load of manure: Differentiating between silvopasture and wooded livestock paddocks in the Northeastern United States. J for 115(1):71–72. https://doi.org/10.5849/jof.16-016

Pannell DJ (1999) Economics, extension and the adoption of land conservation innovations in agriculture. Int J Soc Econ 26(7/8/9):999–1014. https://doi.org/10.1108/03068299910245769

Pattanayak SK, Mercer DE, Sills E, Yang JC (2003) Taking stock of agroforestry adoption studies. Agrofor Syst 57(3):173–186. https://doi.org/10.1023/A:1024809108210

Pent GJ, Greiner SP, Munsell JF, Tracy BF, Fike JH (2020a) Lamb performance in hardwood silvopastures, II: animal behavior in summer. Trans Anim Sci 4(1):363–375. https://doi.org/10.1093/tas/txz177

Pent GJ, Greiner SP, Munsell JF, Tracy BF, Fike JH (2020b) Lamb performance in hardwood silvopastures, I: animal gains and forage measures in summer. Trans Anim Sci 4(1):385–399. https://doi.org/10.1093/tas/txz154

Primdahl J (1999) Agricultural landscapes as places of production and for living in: owner's versus producer's decision making and the implications for planning. Landsc Urban Plan 46:143–150. https://doi.org/10.1016/S0169-2046(99)00038-9

Rogelberg SG, Stanton JM (2007) Introduction: understanding and dealing with organizational survey nonresponse. Organ Res Methods 10(2):195–209. https://doi.org/10.1177/1094428106294693

Ryan RL, Erickson DL, De Young R (2003) Farmers' motivations for adoption conservation practices along riparian zones in a mid-western agricultural watershed. J Environ Plan Manag 46(1):19–37. https://doi.org/10.1080/713676702

Shrestha RK, Alavalapati JRR (2004) Valuing environmental benefits of silvopasture practice: a case study of the Lake Okeechobee watershed in Florida. Eco Econ 49(3):349–359. https://doi.org/10.1016/j.ecolecon.2004.01.015

Shrestha RK, Alavalapati JRR, Kalmbacher RS (2004) Exploring the potential for silvopasture adoption in south-central Florida: an application of SWOT-AHP method. Agric Syst 81(3):185–199. https://doi.org/10.1016/j.agsy.2003.09.004

Strauss AL, Corbin J (1990) Basics of qualitative research. Sage Publications, London

Strong N, Jacobson MG (2005) A case for consumer-driven extension programming: agroforestry adoption potential in Pennsylvania. Small Scale Econ Manag Pol 4(2):215–228. https://doi.org/10.1007/s10457-006-0002-x

Stutzman E, Barlow RJ, Morse W, Monks D, Teeter L (2019) Targeting educational needs based on natural resource professionals' familiarity, learning, and perceptions of silvopasture in the southeastern US. Agrofor Syst 93(1):345–353. https://doi.org/10.1007/s10457-018-0260-4

Trozzo KE, Munsell JF, Chamberlain JL, Aust WM (2014a) Potential adoption of agroforestry riparian buffers based on landowner and streamside characteristics. J Soil Wat Con 69(2):140–150. https://doi.org/10.2489/jswc.69.2.140

Trozzo KE, Munsell JF, Chamberlain JL (2014b) Landowner interest in multifunctional agroforestry riparian buffers. Agrofor Syst 88(4):619–629. https://doi.org/10.1007/s10457-014-9678-5

USDA NASS (2019) 2017 Census of Agriculture: United States summary and state data. Geographic Area Series, vol 1. Part 51. AC-17-A-51

Venkatesh V, Morris MG, Davis GB, Davis FD (2003) User acceptance of information technology: toward a unified view. MIS Q 27(3):425–478. https://doi.org/10.2307/30036540

Villamor GB, van Noordwijk M, Djanibekov U, Chiong-Javier ME, Catacutan D (2014) Gender differences in land-use decisions: Shaping multifunctional landscapes? Curr Optic Environ Sustain 6:128–133. https://doi.org/10.1016/j.cosust.2013.11.015

Walter D (2011) Silvopasture's effect on growth and development of white and black oaks in an intensively managed upland Central Hardwood Forest. Ph.D. dissertation, University of Missouri-Columbia

Wilcoxon F (1945) Individual comparisons by ranking methods. Biom Bull 1(6):80–83. https://doi.org/10.1007/978-1-4612-4380-9_16

Wilkens P, Munsell JF, Fike JH, Pent GJ, Frey GE (2021) Is livestock producers' interest in silvopasture related to their operational perspectives or characteristics? Agroforest Syst. https://doi.org/10.1007/s10457-021-00664-0

Workman SW, Bannister ME, Nair PKR (2003) Agroforestry potential in the southeastern United States: perceptions of landowners and extension professionals. Agrofor Syst 59(1):73–83. https://doi.org/10.1023/A:1026193204801