Agroforest Syst
https://doi.org/10.1007/s10457-021-00664-0

Is livestock producers' interest in silvopasture related to their operational perspectives or characteristics?

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Received: 17 January 2021 / Accepted: 20 July 2021

Abstract Livestock producers' operational perspectives and characteristics are known to be associated with silvopasture adoption, but findings in the literature are mixed and contradictory. To study whether characteristics or perspectives more closely relate to silvopasture interest, 307 livestock producers enrolled in cost-share programs in Virginia, United States of America were surveyed. One hundred and thirty-nine producers responded (rate = 45%). Interest in silvopasture was measured using a Likert-type ordinal scale. Respondents reported the following operational characteristics: size in hectares, type and number of livestock, and primary or secondary occupation. Twelve Likert-type ordinal scales were used to measure the following operational perspectives: financial emphasis, cultural importance, and attitudes pertaining to operational diversification using trees. Multivariate cluster methods were used to group respondents into two classification sets, one based on operational characteristics and the other operational perspectives. Tests for significant differences in silvopasture interest between classifications in each set were conducted using non-parametric Kruskal–Wallis rank sums ($\alpha = 0.05$). Silvopasture interest differed significantly among classifications based on operational perspectives, but not operational characteristics. Cross-tabulations of the two sets and Cramer's V test indicated that the two classification sets are unrelated. Findings suggest silvopasture interest cuts across operation type and is more closely tied to producers' perspectives, particularly views related to diversification. Technical transfer programs and stakeholder engagement should focus on matching perspectives to practice regardless of operational scale and scope.

Keywords Adoption · Agroforestry · Technical transfer · Outreach · Extension

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Introduction

Silvopasture is an agroforestry practice where trees, livestock, and forages are integrated in a single management system (Garrett et al. 2004). Combining animal husbandry, forestry practices, and forage management can achieve multiple benefits such as increased overall farm yield, ecosystem sustainability, and animal welfare (Sharrow et al. 2009; Pent 2020). However, silvopasture requires complex planning

Published online: 24 August 2021

because implementation can be costly, impact forage production, and damage trees and alter habitat, which can lead to system failure (USDA NRCS 2011). Producer engagement and support is important for increasing positive outcomes when agroforestry practices are implemented (Munsell et al. 2018), and silvopasture technical transfer and incentive programs with those goals in mind are gaining momentum in the United States of America (USA) (USDA NASS 2014). Program leaders and other stakeholders will benefit from understanding how operational characteristics and perspectives relate to producers' interest in silvopasture (Orefice et al. 2016; Stutzman et al. 2019).

In their review of agroforestry adoption literature, Pattanayak et al. (2003) found that characteristics such as operation size and type correlated with interest, but associations were both positive and negative. Frey et al. (2012) observed that smaller producers in Argentina were more apt to see benefits tied to adoption. Shrestha et al. (2004) reported the opposite in their study of silvopasture adoption in the southern USA, and Orefice et al. (2016) found that operation size among silvopasture adopters in the northeast USA ranged from 12 to 486 hectares. Other studies across several countries reported no correlation between operational characteristics and adoption (Alavalapati et al. 2004; Perez 2006; Calle et al. 2009). Cubbage et al. (2012) found that smaller producers were the most common agroforestry practitioners in some regions of the world and larger producers in others. Relationships between silvopasture adoption and livestock type and number are less studied, as well as whether livestock production is a primary or secondary occupation.

To study the relationship between producers' perspectives and agroforestry adoption, researchers often use demographic and socioeconomic proxies. Less common are direct measurements of views and opinions pertaining to particular practices, though examples exist. For instance, Meijer et al. (2016) studied how perspectives on tree planting in working farms related to agroforestry adoption in Malawi and Munsell et al. (2018) observed that producers' perspectives regarding benefits of trees in annual agricultural systems were paramount to the retention of intercropping in Cameroon. In the USA, Trozzo et al. (2014a) studied how the process of planning, planting, maintaining, and harvesting tree crops affected agroforestry adoption in the state of Virginia and Shrestha et al. (2004) reported that support for tree-based environmental farming practices were important correlates of silvopasture adoption among producers in Florida.

Income diversification using agroforestry practices is known to be an important economic benefit (e.g., Borremans et al. 2016), but long-term investments and associated risks also can be prohibitive (Trozzo et al. 2014a). Cultural factors override perceptions of risk in some studies (Matthews et al. 1993; Ryan et al. 2003; Strong and Jacobson 2005; Arbuckle et al. 2009; Barbieri and Valdivia 2010), and ecosystem and community services rather than financial returns often are identified by producers as the most attractive benefits of agroforestry (Workman et al. 2003; Munsell et al. 2018). Thus, studying the relationship between livestock producers' underlying operational beliefs and features, and their interests in silvopasture is central to understanding the nature of adoption and manner in which effective technical assistance and outreach programs can be designed.

Whether interest in silvopasture is more closely related to operational characteristics or perspectives was studied by grouping livestock producers in Virginia, USA that responded to a survey into two unique classification sets. One classification was based on operational scale and scope reported by producers in the survey, and the second on their operational perspectives measured using a battery of Likert-type items. Study hypotheses were that silvopasture interest would not differ significantly ($\alpha = 0.05$) among classifications in either of the two operational sets (characteristics; perspectives). Findings point to the relative importance of characteristics and perspectives in adoption, and support development and design of impactful technical assistance and producer engagement initiatives.

Methods

Data for this study and research reported in Wilkens et al. (2021) were collected in Virginia, USA, where livestock production is a prominent agricultural enterprise. The beef cattle industry alone is the state's largest agricultural employer and Virginia overlaps the Southeast, Mid-Atlantic, and Appalachian regions, and is a prime location for silvopasture research. The

state does not maintain an exhaustive list of livestock producers, but the USA Department of Agriculture's Natural Resources Conservation Service (NRCS) state office manages a registry of participants in government-sponsored livestock cost-share programs.

The NRCS participant index in Virginia includes names and postal contact information, and is available upon approval of a Freedom of Information Act (FOIA) request. NRCS personnel compiled names and mailing addresses for the following livestock practice codes: (1) Fencing; (2) Access Control; (3) Brush Management; (4) Prescribed Grazing; (5) Silvopasture; (6) Windbreak/Shelterbelt Establishment; and (7) Tree/Shrub Establishment. A FOIA request was successful, and NRCS personnel supplied contact information for 307 livestock producers who participated in programs during the years 2014–2017.

The delimited list of program participants was mailed a survey instrument designed to measure livestock producers' interest in silvopasture and record their operational characteristics and perspectives, as well as assess silvopasture establishment preferences reported in a companion manuscript (Wilkens et al. 2021). For purposes of this study, characteristics were defined as factors that reflect the structural and functional nature of a livestock operation. These included the number and type of livestock, hectares of operational land, and primary occupation. Perspectives were latent beliefs and opinions about a livestock operation, including the value of agricultural tradition, love of farming, importance of supporting an agricultural economy, and pride in producing food. An emphasis on financial investments, generating personal income, keeping livestock markets competitive, and selling food also were measured, as well as opinions on diversified tree-based management practices, such as planting trees in a pasture, having trees where livestock are managed, thinning forests to graze livestock, and managing trees and cattle together.

To improve survey validity, a panel of livestock producers, farm owners, and forestry and conservation agency and extension personnel evaluated the instrument and provided feedback based on producer trends and experiences, as well as item comprehension. A revised survey was approved by Virginia Tech University's Institution Review Board (IRB# 18–585, approved under 45 CFR 46.110 categories 5 and 7) and distributed following Dillman's Tailored Design Method (Dillman et al. 2009). A pre-notification letter was sent to inform livestock producers of an impending survey, describe the study, and outline parameters for participation. The survey instrument was delivered ten days later with a cover letter and pre-addressed stamped envelope. Following the initial mailing, a reminder postcard was mailed two weeks later to non-respondents. A final cover letter, replacement survey, and pre-addressed stamped envelope were sent a week later.

The wave method (after Rogelberg and Stanton 2007) was used to test for non-response bias. This method matches early responses against late responses following survey methodology research that reports late respondents and non-respondents are similar along a 'continuum of resistance' (Filion 1976; Groves et al. 2001). Researchers use this method to avoid human subject intrusiveness and fatigue when addressing non-response by respecting respondent volition and refraining from contact following completion of the survey cycle. Study variables were evaluated for differences between late and early respondents using independent samples t-tests and cross-tabulations ($\alpha = 0.05$). Noticeable deviations and statistical significance were not observed.

Following a short description of silvopasture and a scientific illustration depicting a mature operation (Fig. 1), respondents reported their general interest on a Likert-type scale ranging from: 1 = 'not interested' to 5 = 'very interested'. An annotated arrow was positioned above the scale to reinforce the direction of incremental increase in interest across the five response anchors. Frequencies and central tendencies were computed and presented to depict baseline interest in silvopasture among all respondents.

Respondents recorded the following operational characteristics: (1) total hectares in livestock production; (2) type of livestock; (3) number of livestock; and (4) whether their operation is a primary or secondary occupation. They also responded to a set of twelve Likert-type ordinal items on a four-point scale that were designed to measure the extent to which producers emphasize financial and cultural factors when considering their operation. Also included in the battery of Likert-type items were questions about tree-based operational diversification. Themes that underpin the structure and function of each item were identified in the literature and shaped by the review panel.

This part of the survey asks you about **silvopasture**, which involves grazing livestock in a well-managed timber stand. The graphic below represents a silvopasture system. This is not woodland grazing, where livestock graze in unmanaged woodlands. Instead, trees and animals coexist using forestry and forage techniques. Please keep your operation and owned/leased land in mind when answering these questions.

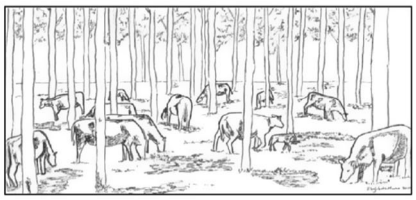

Fig. 1 Silvopasture definition and illustration of a mature silvopasture included in a survey of livestock producers for this study and research reported in Wilkens et al. (2021). (illustration credit: Elizabeth Anderson Moore)

To compare associations between silvopasture interest and operational characteristics and perspectives, two unique classification sets were developed using the same pool of livestock producers. One producer classification set was developed based only on operational characteristics (e.g., size of operation; primary or secondary operation) and a second was developed according to operational perspectives (e.g., importance of cultural attributes; financial emphasis). Two-step cluster method was used to group respondents into a unique classification set based on the four operational characteristics recorded by respondents.

The two-step procedure groups independent observations into clusters using multiple variables, which can be categorical or continuous. Differences and similarities between and among each variable in the test were used to segment producer respondents into classifications, or types, which were statistically differentiated. Silhouette of cohesion depicts the strength of the cluster result. A good cohesion score ranges between 0.5 and 1. The cohesion score and classifications are reported in the results section.

To identify a unique respondent classification set based on operational perspectives, twelve latent perspectives variables were grouped into principal components, which formed the basis for calculating summated constructs. Variables used in the analysis were—reported importance of (1) agricultural tradition, (2) love of farming, (3) supporting an agricultural economy, and (4) pride in producing food; reported emphasis on (1) financial investment, (2) generating personal income, (3) keeping livestock markets competitive, and (4) selling food; and opinions regarding (1) planting trees in pastures, (2) having trees where livestock are managed, (3) thinning forests to graze livestock, and (4) managing trees and cattle together.

Exploratory Factor Analysis (EFA) was used to group the measures into separate components known as factors. EFA is a multivariate statistical analysis used to factor variables with similar relationships in terms of overall variance explained (Gorsuch 1974). Outcomes improve the manageability of large-item datasets by identifying a smaller number of constructs represented by a factored battery of single latent psychosocial measures such as beliefs and opinions about an innovation or behavioral change.

Principal components were selected as the EFA procedure and varimax rotation and Eigen-values greater than 1 were used to factor variables into groups. The Kaiser Meyer Olkin (KMO) test was used to determine if variance in the dataset is the cause of underlying factors and Bartlett's test of sphericity was used to determine if independent items were statistically relatable when identifying those underlying factors. A KMO result of greater than 0.5 indicates likely existence of underlying factors. A significant Bartlett's sphericity result ($p < 0.05$) indicates relatability between independent items.

K-means cluster procedure was used to group respondents into independent classification sets based on the summated construct variables identified using EFA. Similar to two-step clustering, k-means groups independent observations into clusters using multiple variables, but the procedure is restricted to parametric data. Likert-type ordinal data are non-parametric when taken alone, but summated mean scores derived from multiple ordinal responses determined to measure an underlying construct can be assumed to have an underlying parametric continuum, which more accurately distinguishes between respondents (Diday 1976; Spector 1992; DeVellis 2003). Classifications are reported in the results section.

Variations in the data used to create classifications were evaluated in both sets, and differences and trends in each respondent classification were used to create nominal typologies reflecting the nature of the collective result. Nominal classifications were subsequently used as non-parametric factorings to test for statistical

differences in silvopasture interest between the different types of livestock producers within each set ($\alpha = 0.05$). Kruskal–Wallis rank sum scores are reported for both tests in the results section, as are significant differences and mean scores to depict central tendencies.

Because respondents were independently classified twice, the sets were cross-tabulated to depict the frequency distribution of intersected classifications. A Cramer's V (φ_c) test was conducted to determine if the observed distribution of respondents in the cross-tabulation deviate significantly from the expected distribution. Cramer's V was developed following Pearson's chi-square (χ^2) and is commonly used to test for significant associations ($\alpha = 0.05$) between nominal variables with more than two factors. Basic demographic data also are presented in the results section to depict overall trends in respondent characteristics.

Results

Demographics and general operational characteristics

Three-hundred and seven surveys were mailed and 139 returned with a response rate of 45.3%. Survey respondents were almost all male (94.8%), white (98.5%), and over the age of 45 (83.7%). Most had a bachelor's degree or higher and livestock production was a primary occupation for 36.8%. Producers worked primarily with cattle (73.7%), but 8.3% reported managing small ruminants such as goats and 18% reported mixed production systems, which could be any combination of poultry, cattle, or other stock such as sheep. Most survey respondents were concentrated in the mountainous western region of the state (61.8%) where livestock versus plant-crop agriculture is more common, but livestock producers in the Piedmont and Coastal Plain regions also responded (32.4% and 5.9%, respectively).

Silvopasture interest

Silvopasture interest ranged from not at all to very interested, but respondents most frequently reported a moderate level of interest or were slightly inclined toward disinterest (Table 1). When accounting for responses 3 and higher, 65.8% of livestock producer respondents were at least generally interested in silvopasture, but less than 15% were very interested (14.7%). Just over one-third of the respondents (34.1%) reported they were less than interested (indicated by selecting "1" or "2" on the Likert-type scale) and the mean score was slightly below 3.

First classification set—operational characteristics

The two-step cluster method resulted in three classifications derived from four variables depicting a range of operational characteristics (Table 2). Differences in the three operational characteristics variables resulted in the following descriptive titles: (1) larger-scale cattle (n = 39); (2) smaller-scale cattle (n = 50); and (3) diversified (n = 33). The typologies generally reflect operational differences among livestock producers in the state, highlighting distinctions between primary and secondary occupation, cattle-only and mixed production (e.g., ruminants, poultry), and smaller and larger operations. The order of importance for each variable in classifying respondents was (1) type of livestock; (2) primary occupation; (3) hectares in production; and (4) number of livestock.

Larger-scale cattle producers exclusively managed cattle (100%) and for 77% it was their primary occupation. They owned the largest operations among all three classifications with an average of 464 head of livestock on 234 hectares. Smaller-scale cattle producers were also exclusive to cattle (100%), but their operations were not their primary occupation (100%). They managed smaller operations with an average of 86 head of livestock on 88 hectares. Diversified producers managed mixed livestock systems and only a modicum did so as a primary occupation. Their operations averaged 148 head of livestock on 101 hectares.

Second classification set—operational perspectives

The rotated component matrix in the EFA resulted in three factor loadings derived from twelve survey items that explained 60.73% of the total variance (Table 3). The KMO measure of sampling adequacy was 0.696 and Bartlett's test of sphericity was highly significant ($p = 0.000$). Thematic factor loadings reflected perspectives along three distinct perspectives: importance

Table 1 Livestock producer interest in silvopasture calculated using response data from a survey of 307 operations

Overall			Interest increases				
			1 Not interested	2	3 Interested	4	5 Very interested
μ	n	SE	n = 19	n = 25	n = 47	n = 19	n = 19
2.94	125	0.11	(14.7%)	(19.4%)	(36.4%)	(14.7%)	(14.7%)

μ = mean; n = number of respondents; SE = standard error of the mean

Table 2 Classifications of livestock producer respondents based on operational characteristics variables in a two-step statistical cluster procedure

Operational characteristics	Characteristics classification set		
	Larger-scale cattle (n = 39)	Smaller-scale cattle (n = 50)	Diversified (n = 33)
Primary occupation	77%	0%	27%
Cattle-only production	100%	100%	0%
Average number of livestock	464	86	148
Average hectares in production	234	88	101

Silhouette measure of cohesion and separation = 0.6; n = number of respondents; order of overall variable importance in determining classifications: primary occupation, type of livestock, number of livestock, and hectares of production; italicized numbers signify top predictor importance within each classification

Table 3 Rotated component matrix with three EFA factor loadings of 12 survey item responses submitted by livestock producer respondents

Description of survey item	Thematic description of factor loadings		
	Cultural perspective	Financial perspective	Diversification perspective
Importance of Agricultural Tradition	.830	.107	− .026
Importance of Love of Farming	.784	.023	.041
Importance of Supporting Agriculture Economy	.683	.390	.041
Importance of Pride in Producing Food	.598	.388	.073
Emphasis on Financial Investment	.094	.790	.091
Emphasis on Generating Personal Income	.066	.833	.066
Emphasis on Livestock Market Competition	.326	.668	− .165
Emphasis on Selling Food	.174	.657	.012
Opinion about planting trees in pastures	− .131	-.072	.687
Opinion about trees where livestock are managed	.193	-.048	.815
Opinion about thinning forest to graze livestock	.139	.038	.866
Opinion about managing trees and cattle	− .057	.145	.676

Twelve variables grouped into three constructs. Underlined values represent factor loadings. Total variance explained = 60.73%. KMO measure of sampling adequacy = 0.696. Bartlett's test of sphericity (p = 0.000). Values within each loading indicate the portion of variance explained by a particular item

of cultural factors (four items), emphasis on financial returns (four items), and opinions about tree-based diversification (four items). Three classifications were identified using the K-means cluster method (Table 4).

Trends in data used to create the unique set provided a basis for assigning descriptive titles to each operational perspectives classification. 'Balanced and willing' (n = 46) considered both cultural values and financial goals when thinking about their operation, and their opinions about tree-based diversification were not entirely negative. 'Means and opportunities' (n = 26) focus mostly on financial goals when thinking about their operation, and their opinions about tree-based diversification were not altogether dismissive. 'Balanced but resistant' (n = 43) tended to emphasize both cultural aspects and financial goals when considering their operation, but they were highly resistant to the idea of tree-based diversification.

Balanced and willing had the highest cultural perspective and financial perspective mean scores (3.66 and 3.83 respectively), but perspectives pertaining to tree-based diversification (2.36) were slightly less than the means and opportunities classification (2.43). While management perspectives were highest among the means and opportunities classification and financial aspects were important, cultural factors were not as strongly emphasized (2.13). Conversely, balanced but resistant respondents replied unfavorably to the notion of tree-based diversification (1.88), but emphasized the relevance of cultural and financial facets in their operation (2.89 and 3.24, respectively).

Classification comparisons of silvopasture interest

Interests in silvopasture did not differ significantly among livestock producer classifications in the operational characteristics set (Table 5). Larger-scale cattle producers had the lowest rank sum score (52.53), but only slightly lower than smaller-scale cattle producers (56.37). The rank sum score for diversified producers was noticeably higher (67.23), but not enough to produce a statistically significant difference. Interest differed significantly between producer classifications in the operational perspectives set. In this case, rank sum scores in the balanced and open, and means and opportunities classifications were virtually identical (62.07 and 61.54, respectively). The rank sum score for balanced but resistant was noticeably lower (43.88), but only differed significantly when compared to balanced and open producers.

Cross-tabulation of classification sets

Cross-tabulation and Cramer's V results indicate that there was not a significant association between the two classification sets ($\alpha = 0.05$), but the result was on the margin of the assumed threshold for determining significance (Table 6). Interesting residual values include a greater than expected presence of balanced and open producers within the larger-scale cattle classification and a higher than expected rate of smaller-scale cattle producers in the balanced but resistant classification. In addition, diversified producers were observed more than anticipated in the means and opportunities classification.

Discussion

Livestock producer respondents in this study were overwhelmingly older white males, most of whom managed their operations as a secondary occupation.

Table 4 Classifications of livestock producer respondents based on operational perspectives variables in a k-means statistical cluster procedure

Operational perspectives	Perspectives classification set		
	Balanced and open (n = 46) μ (1–4)	Means and opportunities (n = 26) μ (1–4)	Balanced but resistant (n = 43) μ (1–4)
Cultural perspective	3.66	2.13	2.89
Financial perspective	3.83	3.01	3.24
Management perspective	2.36	2.43	1.88

Table 5 Results of a non-parametric Kruskal–Wallis test for significant differences in silvopasture interest between livestock producer classifications in two unique sets (operational characteristics; operational perspectives)

	Characteristics Classification Set		
	Larger-scale cattle (n = 36)	Smaller-scale cattle (n = 49)	Diversified (n = 30)
	Rank Sum Scores (μ 1–5)	Rank Sum Scores (μ 1–5)	Rank Sum Scores (μ 1–5)
Silvopasture Interest	52.53[a] (2.78)	56.37[a] (2.94)	67.23[a] (3.37)
p = 0.16 Kruskal–Wallis H = 3.61			
	Perspectives Classification Set		
	Balanced and Open (n = 39)	Means and Opportunity (n = 49)	Balanced but Resistant (n = 30)
	Rank Sum Scores (μ 1–5)	Rank Sum Scores (μ 1–5)	Rank Sum Scores (μ 1–5)
Silvopasture Interest	62.07[a] (3.17)	61.54[a,b] (3.16)	43.88[b] (2.44)
p = 0.01 Kruskal–Wallis H = 8.49			

Rank sum scores with the same superscript letter are not significantly different after Bonferroni correction for multiple tests. Means are displayed to demonstrate central tendency

Table 6 Cross-tabulation and Cramer's V test results for two classification sets developed using operational characteristics and perspectives among a pool of livestock producers who responded to a silvopasture interest survey

	Characteristics Classification		
Perspectives Classification Set	Larger-Scale Cattle	Smaller-Scale Cattle	Diversified
Balanced and Open	16.8% of total	13.1% of total	10.3% of total
	(observed 18)	(observed 14)	(observed 11)
	(expected 12.9)	(expected 18.1)	(expected 12.1)
	Adj. Residual 2.2	Adj. Residual -1.6	Adj. Residual -0.5
Means and Opportunities	3.7% of total	7.5% of total	9.3% of total
	(observed 4)	(observed 8)	(observed 10)
	(expected 6.6)	(expected 9.3)	(expected 6.2)
	Adj. Residual -1.3	Adj. Residual -0.6	Adj. Residual 2.0
Balanced but Resistant	9.3% of total	21.5% of total	8.4% of total
	(observed 10)	(observed 23)	(observed 9)
	(expected 12.6)	(expected 17.7)	(expected 11.8)
	Adj. Residual -1.1	Adj. Residual 2.1	Adj. Residual -1.2

Cramer's V $\varphi_c = 0.210$ ($p = 0.051$)

Adjusted residuals indicate the relative magnitude of difference between the observed and expected values, where a positive residual indicates more observations than expected and vice versa

USDA agriculture census data indicate there is a greater percentage of minority and women producers in Virginia than included in the respondent pool (USDA NASS 2020), yet cost-share programs often do not reflect full diversity in the agricultural sector and can be confined to wealthier and better-connected producers (Commender et al. 2020). Thus, findings may not represent the perspectives and interests of all livestock producers, but they do assist in exploring the comparative importance of operation type and

producer perspectives in agroforestry adoption. In that regard, the dominance of cattle as a main ruminant is reflective of the nature of livestock production in Virginia, but over 25% of the respondents managed small ruminants or mixed large and small ruminant production systems.

Interest in silvopasture did not differ among livestock producer classifications based on operational characteristics such as operation size, type and number of livestock owned, and whether respondents were full-time producers. There were minor variations, but the extent and variation did not produce a significant result. On the other hand, interest differed significantly across classifications based on producer emphasis on financial factors and the importance of cultural aspects, as well as perspectives regarding tree-based diversification. Balanced but resistant producers were significantly less interested in silvopasture compared to balanced and open producers, but this was not the case when tested against the means and opportunities classification. Perspectives regarding operational diversification using trees is likely the most important factor in the observed contrast, but this was not universal because means and opportunities producers responded most positively to the proposition and yet did not differ significantly from balanced but resistant.

Some studies report that operational characteristics are critical factors affecting silvopasture adoption (Arbuckle et al. 2009), while others submit that opinions, perspectives, culture, and identity are most influential (Shrestha et al. 2004). Research focused on the relationship between scale of production and silvopasture adoption is somewhat common (Frey and Comer 2018), as well as studies regarding the role of tree planting perspectives and operational diversification (Meijer et al. 2016). Without question, agroforestry requires time and effort that can be prohibitive, but studies also indicate these barriers are surmountable when attitudinal alignment occurs whether operations are large or small, diversified or not (Current et al. 1995; Trozzo et al. 2014b; Borremans et al. 2016). However, this study did not assess whether the type of production system (e.g., cow-calf), and animal units and land base requirements influence interest, which likely are important factors for future research.

That there is no significant relationship between classification sets suggests diverse producer perspectives cut across operational characteristics. This implies that differences in the balance of cultural and financial factors, and opinions related to tree-based diversification are prime considerations when considering how, when, and where to engage livestock producers regarding silvopasture technical assistance, and reactions to the notion of tree planting are prime but not altogether singular. Findings along these lines are supported by previous research where culture and identity are most strongly related to agroforestry interest (Matthews et al. 1993; Ryan et al. 2003) and opportunities for diversification increase interest (Current et al. 1995; Shrestha et al. 2004).

When matched against existing literature, findings in this study present important implications for agroforestry adoption research, as well as associated technical assistance and engagement programming. For one, interest is not necessarily a product of scale, though the size and nature of an operation are critical in terms of the type of application and requirements for sustaining a successful enterprise. Differently for outreach to livestock producers, and thus technical training that helps avoid system failure, is the role of marketing opportunities to producers. Crafting silvopasture training programs or other communication and engagement strategies driven first by scale may overlook and underestimate producer segments that are interested in silvopasture. Scale is likely to affect whether a producer eventually adopts the practice, but this research suggests that will not singularly be the case. It may be that the rate of adoption is ultimately similar across all types of operations with producer perspectives and improvements in tree management strategies and demonstrations being cornerstones.

This study provides insights about silvopasture adoption for policymakers, extension agents, research institutions, and producer organizations. Livestock producers have values and beliefs that extend beyond operational attributes that are influential in their decision-making. Those whose perspectives lean toward interest are likely found across a variety of organizations and networks servicing diverse operational structures and functions. Efforts to position silvopasture as an agroecological practice that balances farm output and environmental services are growing among production and conservation stakeholders. Interest in silvopasture exists among large and small producers who manage all forms of livestock as a primary or secondary operation. The ways in which they think about their operations, on the other hand,

relate to different interests, which implies perspectives will matter more in the trajectory of silvopasture adoption.

Conclusion

Interest in silvopasture among livestock producer respondents ranged from complete disinterest to highly interested, with the largest number using the middle response anchor (36.4%) and a mean score of slightly below 3. The distribution of responses has a slight positive skew because the next most common anchor response moved toward disinterest (19.4%) and the mean indicates this position is most common. Yet 29.4% (n = 38) recorded anchor responses of 4 and 5, which were on the upper end of the interest scale. This is a relatively common observation in agroforestry adoption research, where some respondents are curious or highly enamored with the proposition while others are less than interested or outright opposed. Trends in previous studies tend to indicate that specialty, smaller-scale producers, females, and more capitalized producers often comprise significant portions of the curious or charmed (e.g., Strong and Jacobson 2005; Trozzo et al. 2014b), but there are exceptions (Pattanayak et al. 2003).

Respondent classifications in this study indicate there are operational characteristics and perspectives among livestock producers that can be used to distinguish unique differences in the sector. Three classifications in a set based on operational characteristics identified larger-scale cattle only producers, smaller-scale cattle only producers, and diversified producers. While cattle dominated the ruminant matrix, Virginia hosts a spectrum of livestock operations and representative producers participated.

A battery of psychosocial survey items pertaining to the role of cultural and financial factors in operational perspectives, as well as reactions to tree-based diversification resulted in three classifications. The set included producers who balance financial and cultural factors, and are not necessarily dismissive of tree-based diversification, as well as those that think about their operation largely in terms of financial aspects and are ardently opposed to tree-based diversification. Taken together, both classification sets constitute a comparative pathway for examining interest in silvopasture, which is important given variation in the literature regarding significant associations.

Livestock producers that seek to build resilient agricultural systems are on the rise and silvopasture is at the forefront. Those that work to support silvopasture stakeholders will benefit from additional precision regarding how producers perceive this practice and the extent to which diverse outlooks relate to interest and potential adoption. Overall adoption of silvopasture is generally low, but the benefits are increasingly clear and efforts to increase sustainable agroecological farms and shape policies and outreach strategies depend upon effective communication and comprehension of the broad spectrum of producer perspectives and opinions.

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