SILVOPASTURE INTERESTS AMONG LIVESTOCK PRODUCERS IN VIRGINIA

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Abstract (Academic)

Silvopasture is a land-use management practice which intentionally integrates trees, forage, and livestock. It is increasingly prevalent in outreach and extension, yet considerations for adoption are complex. The implementation of a cost-share initiative for silvopasture created by the Natural Resource Conservation Service (NRCS) in Virginia in 2011 provides an opportunity for landowners to establish silvopasture systems on their properties, thus diversifying land management and income, as well as providing environmental benefits. However, research on who might adopt silvopasture and why is needed. For this research, a mail survey was distributed to 307 cost-share enrollees in NRCS' livestock limitation initiatives and 139 were returned (45.3%). The first objective of this survey was to gauge interest in two forms of silvopasture implementation: a) thinning a woodlot and b) planting trees in a pasture. Furthermore, the study was utilized to test which hypothetical benefits might increase a livestock producers' interest in either implementation form. Results show that respondents preferred thinning to planting but risk and uncertainty were perceived in both. Environmental outputs and assistance from technicians increased interest in both practices over economic benefits; however, livestock performance was most important. Literature on the topic aligns with findings and highlights that more research is needed to understand risk, environmental, and resource-related factors.

The second objective was to measure interest in silvopasture and classify respondents based on their operational or their beliefs-based characteristics and assess

which classification set mattered more. Results indicated that interest in silvopasture varied but the majority (60%) indicated they were either interested or very interested. Two-step cluster analysis was used to classify respondents based on their operational considerations and a combination of Exploratory Factor Analysis and K-means clustering was used to group livestock producers according to their beliefs on traditional and land-use values. A Kruskal-Wallis independent samples analysis for each classification revealed no statistically significant differences in the interest in silvopasture between operational groupings. Conversely, there were statistically significant differences in silvopasture interest according to beliefs-based classifications. These results suggest that operations of livestock producers do not matter as much as their attitudes and beliefs related to the practice. A cross-tabulation of the operational classification and beliefs cluster resulted in no correlation. Literature suggest both operational characteristics and producer beliefs may matter in agroforestry adoption, but that positive or negative correlation in terms of interest may vary.

Silvopasture interests among livestock producers in Virginia

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Abstract (General Audience)

Silvopasture is a agroforestry conservation practice that integrates trees, forage, and livestock in a managed system. The adoption of this practice is complex, though education on the practice has been increasing. A cost-share initiative for silvopasture was created by the Natural Resource Conservation Service (NRCS) in Virginia in 2011, which creates the opportunity to implement silvopasture systems on landowner properties. This system could lead to more diversification of land and income, as well as providing environmental benefits. However, more research is needed. A mail survey was sent to 307 NRCS cost-share enrollees who were managing livestock and 139 were returned. The survey had two objectives; the first was to measure interest in the two forms of silvopasture implementation: a) thinning a woodlot and b) planting trees in a pasture. Hypothetical benefits which might increase a livestock producers' interest in thinning or planting for silvopasture was also measured. Results show that respondents had a preference for thinning over planting. Economic benefits were not as effective in increasing interest compared to environmental outputs and assistance from technicians; however, livestock performance was most important. Findings were aligned with literature on silvopasture and agroforestry but more research is needed.

The second objective was to measure interest in silvopasture and classify respondents based on their operational or their beliefs-based characteristics and to see which classification set mattered more. Results indicated that interest in silvopasture varied but the majority (60%) indicated some level of interest. Statistical analyses were

used to classify respondents based on their operational considerations and used to group livestock producers according to their beliefs on traditional and land-use values. Outputs showed no statistically significant differences between operational groupings and their interest in silvopasture. There was a statistically significant difference in silvopasture interest according to beliefs-based classifications. These results indicate that the operations of livestock producers do not matter as much as their attitudes and beliefs on the practice. Previous literature indicates that both operational characteristcs and producer beliefs may matter in agroforestry adoption, but interest may vary regardless.

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List of Abbreviations

AFTA	Association for Temperate Agroforestry
DOF	Department of Forestry
EFA	Exploratory Factor Analysis
FOIA	Freedom of Information Act
KMO	Kaiser Meyer Olkin
NRCS	Natural Resource Conservation Service
USDA	United States Department of Agriculture
UTAUT	Universal Theory of Acceptance and Use of Technology

Chapter 1 Introduction

1.1 Background

Silvopasture is an intensive management practice combining livestock, trees, and forage. The system can be utilized to reduce compaction on soils and livestock heat stress, improve and more conscious management of forests (Feldhake 2009; Cubbage et al. 2012). Silvopasture has two distinct types of implementation: thinning an existing woodlot or planting trees in existing pasture for livestock to graze underneath (Karki 2015).

Silvopasture is one of the five temperate agroforestry practices, along with riparian buffers, windbreaks, alley cropping, and forest farming (Gold and Garret 2009). Agroforestry can be defined as an intensive, integrative, intentional, and interactive management practice that combines trees and shrubs with crops and/or livestock and has been a focus of government cost-share programs in recent years (NRCS 2011; Orefice and Carroll 2017). Silvopasture can provide many benefits to forest and livestock, including shading, additional fodder for animals, increased soil fertilization, and understory vegetation management (Fike et al. 2004). Silvopasture was adopted as a livestock cost-share initiative by the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) for their cost-share programs that assist United States (U.S.) farmers with conservation practices on their working lands.

1.2 Problem Statement

Silvopasture systems, when appropriately managed, provide shade for livestock, encourage grasses to grow, reduce soil erosion, and provide income from timber (Moorhead and Dickens 2012). In the Southeastern U.S., silvopasture is a relatively common agroforestry practice, but awareness – let alone adoption – remains low (Workman et al. 2003). Nevertheless, there is potential for silvopasture on 179 million acres of land in the U.S., which is estimated

based on the amount of pastures and grazed forests in the United States (NASS 2012). Silvopasture can assist in diversifying small-scale, private farmlands which will, as a result, diversify income streams for those landowners (Barlow 2010). Though there are potential benefits to adoption of silvopasture, its complexity (i.e. managing trees, livestock, and forage together) suggests that it may one of the more difficult agroforestry practices to adopt (NRCS 2011). Common constraints include livestock exclusion, lengthy time investments, and lack of knowledge about the practice (Warren et al. 2011; Bussoni et al. 2015).

Challenges associated with silvopasture systems also impact the perceptions and preferences producers have about adopting silvopasture. This research addresses how landowner perspectives about silvopasture and studies the reasons they feel that way.

1.3 Objectives

The goal of this research was to understand livestock producers and their perspectives on silvopasture. The two objectives included: a) understanding livestock producers and how they perceive thinning trees in a woodlot or planting trees in a pasture to establish silvopasture and b) understanding silvopasture interest among livestock producers and whether their interest is better explained according to their operations or beliefs. Findings will inform existing literature on agroforestry and silvopasture adoption and lead to an increased understanding of producers in Virginia who have the potential to adopt the practice.

1.4 Organization

Chapter Two reviews the literature about agroforestry in general, and silvopasture more specifically, and the adoption of the two practices. It highlights the conceptual model used for hypothesis building and research design. Chapter Three focuses on the interests of respondents in thinning trees out of a woodlot or planting trees in a pasture. Chapter Four focuses on two

classification sets rendered from respondents. The first is based on operational characteristics and the other respondent beliefs. Chapter Five reiterates results, discusses most consequential implications of the research, and articulates next steps.

Chapter 2 Literature Review

2.1 Temperate Agroforestry

Agroforestry is an intensive land-use system that improves physical, biological, ecological, and social interactions created by the combination of trees and shrubs with crops and/or livestock (Garrett et al. 2004; Gold and Garrett 2009). Temperate agroforestry is defined by four criteria: intentional, intensive, integrated, and interactive (Merwin 1997; Gold and Garrett 2009). The Association for Temperate Agroforestry (AFTA) further distributes agroforestry into subsets for the U.S. and Canada: riparian and upland buffers, windbreaks, alley cropping, forest farming, and silvopasture. Silvopasture is the management of trees with forage and livestock production (Gold and Garrett 2009; NRCS 2011; Fike 2014).

The intensive nature of agroforestry demands a great level of investment and planning, which further necessitates a deeper understanding of both the technical aspects and preferences for adoption. Research on both helps to accelerate successful implementation of projects (Pattanayak et al. 2003). Two recent agroforestry studies done in Virginia used findings of Pattanayak et al. (2003) on agroforestry and found that biophysical factors (e.g., soil loss), system design, and demographic factors (e.g., age, income, etc.) play a role in the adoption and retention of agroforestry practices such as conservation buffers (Trozzo et al. 2014; Commender et al. 2016).

More broadly, Matthews et al. (1993) studied landowner interest in agroforestry and found that most were familiar and interested in the practice but still had economic concerns. Other research differs, finding that issues of land tenure (Montambault and Alavalapati 2005; Arbuckle et al. 2009), environmental outcomes (Valdivia et al. 2012), and land management objectives (Strong and Jacobson 2005) among others are more important in temperate systems.

Similarly, silvopasture has been research to understand the factors that impact the practice (Workman et al. 2003; Fike et al. 2004; Montagnini and Nair 2004; Shrestha and Alavalapati 2004; Mayerfeld 2016; Orefice and Carroll 2017; Pent and Fike 2019).

2.2 Silvopasture

Silvopasture is an intensive land-and-livestock practice that intentionally combines trees, forage, and livestock in a managed system (Orefice and Carroll 2017). The practice, often utilized to diversify production, has been studied regarding biophysical characteristics (Frey et al. 2016), economic benefits and constraints (Cubbage et al. 2012; Strong and Jacobson 2016), and environmental and production outputs (Montagnini and Nair 2004; Shrestha et al. 2004; Pent and Fike 2019).

Generally speaking, there are two pathways for establishment: thinning woodlands or planting trees in pasture (Karki 2015). Thinning forested areas requires consideration of livestock exclusion, timing of the thinning events, and optimal light penetration for forage growth underneath the canopy (Orefice and Carroll 2017). Planting trees in a pasture necessitates other considerations, including selecting ideal tree species, fencing, and preparing sites for planting and protecting trees or taking land out of pasture until trees are big (Karki 2015). These two separate implementation methods have been studied separately, regarding best management practices and considerations for implementation (Fike 2014; Lindgren and Sullivan 2014). However, a gap in the literature exists in terms of comparing interest in the two approaches among potential adopters of the two practices.

Silvopasture is used in various regions of the world (Lindgren and Sullivan 2014). Several apparent advantages exist to including trees in a livestock production system, including reduced heat stress from shading livestock (Workman et al. 2003; Walter 2011; Cubbage et al.

2012; Pent, Fike, and Kim 2018). In addition, several studies have highlighted environmental benefits, such as water quality improvement and carbon sequestration (Montagnini and Nair 2004; Shrestha and Alavalapati 2004). In a review of eight silvopastoral systems throughout the world, Cubbage et al. (2012) outline the most common benefits. These include higher profits, improved microclimate, lower risk of forest fire, diversification of business practices, shade and shelter for livestock, minimizing frost, carbon sequestration, and brush control. Mayerfeld et al. (2016) found that livestock producers in the Midwest of the U.S. observed improvements to management of woodlands and savannahs by using silvopasture. Furthermore, the resiliency of trees adds benefits if a certain area or zone faces pasture loss due to weather extremes (Cubbage et al. 2012).

Though there are numerous studies pertaining to the advantages of silvopasture, other research projects have identified a common set of perceived disadvantages. Included in these disadvantages are potential tree damage from animals, the time investment of silvopasture, fire risks, potential soil compaction, and risk associated with governmental regulations (Shrestha and Alavalapati 2004; Cubbage et al. 2012; Mayerfeld 2016; Orefice and Carroll 2017). Furthermore, silvopasture requires intensive management as improper implementation can lead to higher costs, reduction of forage, and overall failure of the system (NRCS 2011).

Over 2,500 farms in the US practice silvopasture or alley cropping, yet the potential for adoption is much higher (NASS 2012; MacFarland 2015). Therefore, understanding the biophysical, environmental, and economic components will be imperative to formulating a complete picture of the true potential silvopasture and similar conservation practices have to offer. As species and climate vary from region to region, special considerations on area adoption studies are needed (Frey et al. 2016).

2.3 Adoption of Agroforestry Practices and Silvopasture

Agroforestry adoption is intensive and begets a more complex adoption process. Agroforestry practitioners are more likely to be successful if they make greater investments, both physically and intellectually (Commender et al. 2016; Mercer 2004). Montambault and Alavalapati (2005) reviewed a decade of agroforestry literature and found socioeconomic research to be lacking but not altogether absent. Common areas of research include demographics, such as education (Cooper and Jacobson 2009), income (Featherson and Goodwin 1993), land tenure (Matthews et al. 1993; Current et al. 2005; Borremans et al. 2016; Mayerfeld et al. 2016), and socioeconomics or economic analyses (Current et al. 1995; Loomis et al 2000; Mongtagnini and Nair 2004; Montambault and Alavalapati 2005). Lastly, perceptions of risk and uncertainty is a significant driver in agroforestry interest but mediating factors such as experience, extension and training, membership in a community organization, or land tenure can play a role in actual implementation (Pattanayak et al. 2003; Trozzo et al. 2014).

With silvopasture specifically, low adoption rates have led to many studies on adoption of the practice (Frey et al. 2016). These studies generally focus on operational considerations and attitudes about the economic, environmental, or technical considerations for silvopasture. Regarding operational considerations, biophysical interactions (e.g., size, type) have been found to play a role in silvopasture adoption, whether positive or negative (Pattanayak et al. 2003; Warren et al. 2012). However, other studies have found little relationship between the two (Alavalapati et al. 2004; Perez 2006). The same discontinuity holds true for operational considerations of agroforestry adoption, more generally (e.g., Mercer 2004; Arbuckle et al. 2009).

Beliefs and attitudes also are present in the literature but are somewhat nuanced. Pattanayak et al. (2003) posits that there are proxies for belief variables used in studies of adoption, such as age, gender, or socioeconomics, but belief itself is rarely studied (Mercer 2004). However, Shrestha et al. (2004) found that increased landowner interest in environmental benefits and connection with the land, but governmental policies were a known limitation. With respect to agroforestry in general, beliefs about income diversification (Borremans et al. 2016) were found to be considered a benefit and long-term investments a risk (Trozzo et al. 2014). However, other studies have pointed to factors that supersede financial considerations, namely cultural, aesthetic, and effort-related considerations (Matthews et al. 1993; Ryan et al. 2003; Strong and Jacobson 2005; Arbuckle et al. 2009; Barbieri and Valdivia 2010).

In agricultural adoption studies of agriculture more generally, results are similar. Many studies indicate that knowledge, land suitability, and landowner's identity all play an influential role in technology adoption (Winsten et al. 2010; McCutcheon et al. 2015). These variations in the literature show that various factors correlate with interest or disinterest in a practice. For this research, a theoretical framework is used to conceptualize the critical components of silvopasture adoption.

2.4 Conceptual Framework: Adapted UTAUT and Agroforestry Concepts

Trozzo et al.'s (2014) adaptation of the Universal Theory of Acceptance and Use of Technology (UTAUT) model was used as the primary theoretical framework in this study. This framework was originally conceptualized as a unified model for information technology (Venkatesh et al. 2003). Trozzo et al. (2014) modified this framework by including risk and biophysical factors as proposed by Pattanayak et al. (2003). This model posits that certain factors play a role in the adoption of agroforestry practices (Figure 2.1)

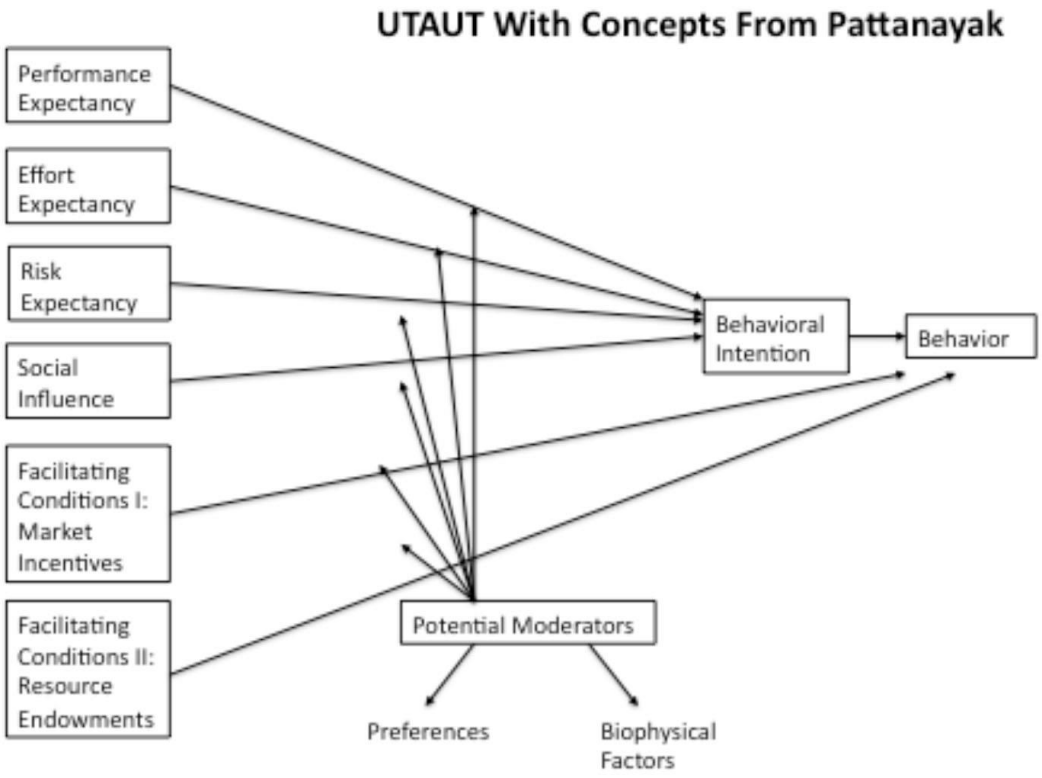

Figure 2.1 The UTAUT Agroforestry Adoption model adapted and published by Trozzo et al. (2014)

In terms of silvopasture, performance expectancy or how well the technological adoption is expected to perform, gauges how livestock producers think silvopasture will perform on their land. Effort expectancy measures how much expected work livestock producers believe they would have to exert to implement and manage silvopasture. Risk expectancy indicates the level of risk or uncertainty there is in adopting this practice, whether from environmental, economic, or other factors. Lastly, social influence is how much a livestock producer is influenced by social ties (e.g., family, neighbors, other producers, etc.).

Facilitating conditions move from interest or intention to implementation of the practice. Market incentives measure to what extent finances and the costs of the operation influence a livestock producer's behavior and, resource endowments would include the available help and support of extension agents or government programs. Preferences, as potential moderators, assist

in understanding the characteristics of livestock producers (e.g., age, sex, income) and how those impact interest. Biophysical factors consider the climate, size, location, and type of production and its impact on silvopasture.

Trozzo et al. (2014) found that performance expectancy, risk expectancy, social influence, and biophysical factors impact interest in adopting multi-functional agroforestry buffers. Furthermore, Commender et al. (2016) utilized the adapted model of UTAUT and found that performance expectancy and social influence play a role in interest of multifunctional conservation buffers. These studies were used to guide research to study the influence of performance expectancy, risk expectancy, preferences, and biophysical characteristics in silvopasture adoption.

2.5 Summary

Agroforestry is land-use management practice that integrates trees into animal or crop farming systems with silvopasture as a subset intentionally integrates trees, livestock, and forage. These practices can enhance environmental outcomes and diversify production of the system. Yet, adoption of these practices is still low. As a result, literature on the adoption of agroforestry and silvopasture has been increasing. Topics often include operations and demographic characteristics, as well as attitudes about the practices. The previous research, as well as a conceptual framework, has helped guide this research on silvopasture interest. Findings can contribute to literature on agroforestry and silvopasture adoption preferences by measuring interest based on implementation types and operational or beliefs-based classifications. This can inform outreach and extension related to conservation of land.

Chapter 3 Thinning Forests or Planting Fields? Producer Preferences for Silvopasture Establishment

Abstract

Silvopasture is an agroforestry practice that integrates forages, livestock, and trees in the same space. Policy, extension, and outreach on the practice are increasing in the United States. For example, Virginia's Natural Resources Conservation Service has offered a silvopasture cost-share program since 2011. Research on silvopasture adoption indicates interest in the practice varies, but the focus of these inquiries largely has been on field plantings and the general landowning population. In places where silvopasture is formally supported through policy, studying cost-share participant interests and preferences will improve our understanding of potential adoption among engaged livestock producers. To that end, we studied preferences for: a) thinning forests, or b) planting trees in fields to establish silvopasture among Virginia producers that participate in cost-share programs. Research objectives were to measure producer interests in these two forms of silvopasture establishment and evaluate the extent to which a set of hypothetical benefits for each increases their interest. We sent surveys to all the 307 enrolled livestock producers in Virginia, USA. One hundred and thirty-nine responded (45%). Respondents preferred thinning existing forests to planting trees in pastures, but perceived risk in both. Interest tended to increase when environmental improvements and technical assistance followed adoption, as opposed to financial gains. Results suggest that enhanced performance of livestock operations was most important. Reducing risk in primary forms of production aligns with literature on uncertainty in agroforestry adoption, but additional research is needed in terms of preferred objectives.

3.1 Introduction

Agroforestry is a land use that integrates agriculture and forestry (Garret et al. 2004). In temperate landscapes, there are five practices: windbreaks, riparian and upland buffers, alley cropping, forest farming, and silvopasture (Gold and Garrett 2009). Silvopasture integrates trees, livestock, and forage into a single managed pasture system (Orefice and Carroll 2017). It provides shade for livestock, encourages warm season grass growth, reduces soil erosion, and provides income from timber (Pimentel 1995; Kurtz 2000; Workman et al. 2003; Moorhead and Dickens 2012).

Generally speaking, there are two ways to establish silvopasture. One involves thinning a forest and the other planting trees in a pasture. These approaches require different management strategies, and adoption varies based on landowner objectives and the land they manage. In order to covert a forest to silvopasture, one or more thinnings may be necessary to achieve an appropriate amount of sunlight for forage growth while also managing forest health and productivity (Karki 2015). Furthermore, livestock must be contained and managed, so they do not damage residual tree stems (Orefice and Carroll 2017). On the other hand, tree species selection, site preparation, and fencing are important when establishing silvopasture in an open field (Karki 2015).

In the U.S., 2,725 farms of over 2 million reported practicing alley cropping or silvopasture, while there are an estimated 179 million acres suited for the practice (NRCS 2011; NASS 2012). Yet adoption remains low, with less than 1% of US farmers practicing silvopasture (Workman et al. 2003; Fike et al. 2004; NASS 2012). Studies show that landowners and agencies alike largely avoid integrating trees and livestock (Mayerfeld 2016). However, attention to silvopasture is increasing (Orefice and Carroll 2017), particularly considering growing interests

in associated environmental benefits, including carbon sequestration and water quality (Montagnini and Nair 2004; Shrestha and Alavalapati 2004).

Silvopasture adoption research has focused on perceptions, establishment methods, and biophysical interactions (Frey et al. 2016). Cubbage et al. (2012) cite cultural, geographic, and market-related issues as potential constraints. Strong and Jacobson (2005) found that landowners in Pennsylvania placed high importance on environmental factors and economic returns when considering whether to adopt. Though silvopasture was not widely used in Pennsylvania, landowners were very interested. They noted shading for livestock as a primary benefit and technical and marketing information as a large constraint. These findings reinforce technical and financial assistance programs, such as the USDA's NRCS national initiative in 2002 and state level cost-programs like that initiated in Virginia in 2011.

In relation to agroforestry adoption more broadly, Montambault and Alavalapati (2005) reviewed agroforestry literature and found that socioeconomic studies were lacking. Up to that point, most agroforestry research focused on basic biophysical dynamics and the authors suggested that social factors were understudied. Since then, adoption studies have increased, and the themes highlighted in the agroforestry adoption literature generally separate into demographics, operational considerations, and anticipated outcomes. Matthews et al. (1993) found that age positively correlated with interest in agroforestry adoption. Additionally, other studies show that increased income (Featherstone and Goodwin 1993) and education (Cooper and Jacobson 2009) correspond to interest in agroforestry.

For operational considerations, Mayerfeld et al. (2016) found that land tenure played a significant role in the interest of farmers in southwest Wisconsin. A comparable finding was highlighted in a study done by Current et al. (1995) in Central America and the Caribbean.

Borremans et al. (2016) found similar results in Belgium and Matthews et al. (1993) found that interest was highest among those who owned between 10-100 acres.

Economics and cost-benefit analyses on agroforestry adoption has been studied extensively. Current et al. (1995) showed that the estimated financial return of prominent agroforestry practices in Latin America was important to a landowner's decision to adopt. Montagnini and Nair (2004) found that there was a willingness to pay that speaks to the economic constraints of agroforestry and the need for public policy to support the practice for adoption to increase. In the same study, the authors highlighted that perceived environmental benefits increased a landowner's interest in silvopasture. Current et al. (1995) noted that farmers tended to place importance on the overall system design of an agroforestry practice. Other studies have also highlighted financial constraints, as well as time and effort of agroforestry implementation (Current et al. 1995; Borremans et al. 2016).

Lastly, risk is a common correlate in agroforestry adoption studies (e.g., Trozzo et al. 2014). Pattanayak et al. (2003) found that risk, biophysical variables, and resource endowments were most likely to influence agroforestry adoption, but other factors were also influential. In the conservation agriculture literature, studies suggest farmers are traditionally risk averse and place higher emphasis on negative rather than positive outcomes when making decisions (Pannell 1999).

Specific to agroforestry, risk and uncertainty can be belied by land tenure, experience, extension and training, and membership in community organizations (Pattanayak et al. 2003). However, very few studies focus explicitly (Mercer 2004). Trozzo et al. (2014) found that risk and biophysical factors were significant predictors of interest in multifunctional riparian buffers. Perceived risk was found to be a powerful predictor of interest in their study.

We studied perceptions about silvopasture establishment among livestock producers enrolled in USDA NRCS cost-share programs in Virginia. We measured interest in establishing silvopasture by thinning forests and planting trees in pastures. Producer respondents also were asked to respond to a set of questions designed to indicate the extent to which hypothetical benefits (or "activators") associated with each form of silvopasture establishment would increase their interest. We sought to test whether there is a difference in interest levels related to these two forms of silvopasture establishment and the extent to which different outcomes increase interest. Results help understand preferences for silvopasture establishment and identify outcomes that may be more influential.

3.2 Methods

Three-hundred and seven Virginia livestock producers enrolled in NRCS livestock limitation cost-share initiatives in Virginia were surveyed. Limitation initiatives included: Access Control, Brush Management, Fencing, Prescribed Grazing, Silvopasture Establishment, Tree/Shrub Establishment, and Windbreak/Shelterbelt Establishment. The names and contact information of those enrolled were gathered through the Freedom of Information Act (FOIA) and NRCS provided these data for program enrollment during the years 2014-2017.

A survey instrument was developed based on silvopasture adoption literature, including hypothetical environmental, economic, and resource-related measurements. An expert panel was consulted based on their familiarity with livestock producers in the state and their experience with the adoption of silvopasture and/or conservation practices. The survey was edited and then distributed via mail.

Participants were surveyed using Dillman's Tailored Design Method (Dillman et al. 2009). This entailed a pre-notification letter informing participants of a forthcoming survey and

encouraged their participation. Ten days later, the survey instrument, a cover letter, and a pre-addressed stamped envelope were mailed to all participants. Two weeks later, a reminder postcard was sent out, which was followed by a replacement cover letter, envelope, and questionnaire a week later.

The survey instrument measured characteristics such as years spent farming, acres of land owned, and type and quantity of livestock, as well as demographic variables (e.g., age, sex, race, income, and education). A general silvopasture illustration was provided (**Error! Reference source not found.**), and a short definition of each approach (thinning, planting) was provided. Furthermore, it measured interest in both forms of silvopasture implementation: 1) *thinning* an existing woodland (thinning); and 2) *planting* trees in a pasture (planting). A Likert-type scale was used for both interest measures and spanned from: 1 – "I am not interested"; 3 – "I am interested"; and 5 – "I am very interested". Following each interest item, a single open-ended question asked respondents to clarify their answer.

A series of scales were then presented to measure the extent to which particular outcomes from silvopasture adoption, for thinning and planting, increases their interest.

Figure 3.1 Definition and illustration of silvopasture to preface questions about interest in silvopasture within the survey instrument distributed to sample population

Activator variables were measured using the following scale: 1 “No interest”; 2 “A little bit”; 3 “A fair amount”; and 4 “A lot”. Variables were based on frameworks of agroforestry interest published in Pattanayak et al. (2003) and Trozzo et al. (2014). The activator measures for each of those two variables (*thinning* and *planting*) were related to economic, environmental, resource-, and effort-related questions. For *thinning*, each variable was compared to the others for ranking differences by using the Wilcoxon-Signed Rank Test (Table 3.1). Four activators were identified: *Improve Health of Woodlot, Profit from Thinning, Pasture Break,* and *Forester Assistance.*

Table 3.1: Activator variables and their equivalent framework indicator to measure extent of interest increased for thinning woodlots to create silvopasture

Variables for increasing interest in thinning	**Conceptual Framework Equivalent**
Improving the health of the woodlot	Performance Expectancy
Making a profit from the thinning	Market Incentives
Open pastures would get a break	Performance Expectancy
A forester helps mark and market the thinning	Market Incentives/Resource Endowments

For *planting* interest, each activator variable was also compared by ranking with the Wilcoxon-Signed Rank Test (Table 3.2). These activators aligned with frequently cited literature regarding the benefits and challenges of silvopasture adoption. These activators are *Shade for Livestock, Environmental Payments, Profit from Timber, Cost-Share Assistance* and *Adequately Budgeted Time and Protection.*

Table 3.2 Activator variables to measure extent of interest increase for planting trees in a pasture to create silvopasture

Variables for increasing interest in planting	**Conceptual Framework Equivalent**
Livestock would benefit from the shade	Performance Expectancy
There would be environmental payments	Performance Expectancy
The long-term timber returns would be highly profitable	Market Incentives
NRCS provides technical and cost-share assistance	Market Incentives/Resource Endowments
The time and protection needed fits within my farm budget	Effort Expectancy

Data Analysis

Frequencies were used to study the characteristics and demographics of the respondents. A Wilcoxon-Signed Rank Test was used to test for significant differences in respondent interests in thinning and planting to establish silvopasture and for differences between the measures of how outcomes activate their interests in the two implementation methods. Qualitative data were analyzed by themes created from codes. Code frequencies were analyzed using counts and open-ended comments were selected for qualification.

3.3 Results

Three hundred and seven surveys were delivered to NRCS limitation cost-share program participants in the state of Virginia. One hundred and thirty-nine surveys were completed and returned for a response rate of 45.3% (Figure 3.2). Respondents were primarily white males between 45-64 years of age (Table 3.3). Most had at least a bachelor's degree and a household income of $50,000-100,000 USD. The vast majority managed cattle, though others noted sheep, goats, poultry, and other specialty livestock were part or all their operations. Most stated livestock production was not their primary occupation. Respondents owned an average of 330 acres. Of that, an average of 51 acres were reported as being forested. Respondents had farmed an average of 31 years.

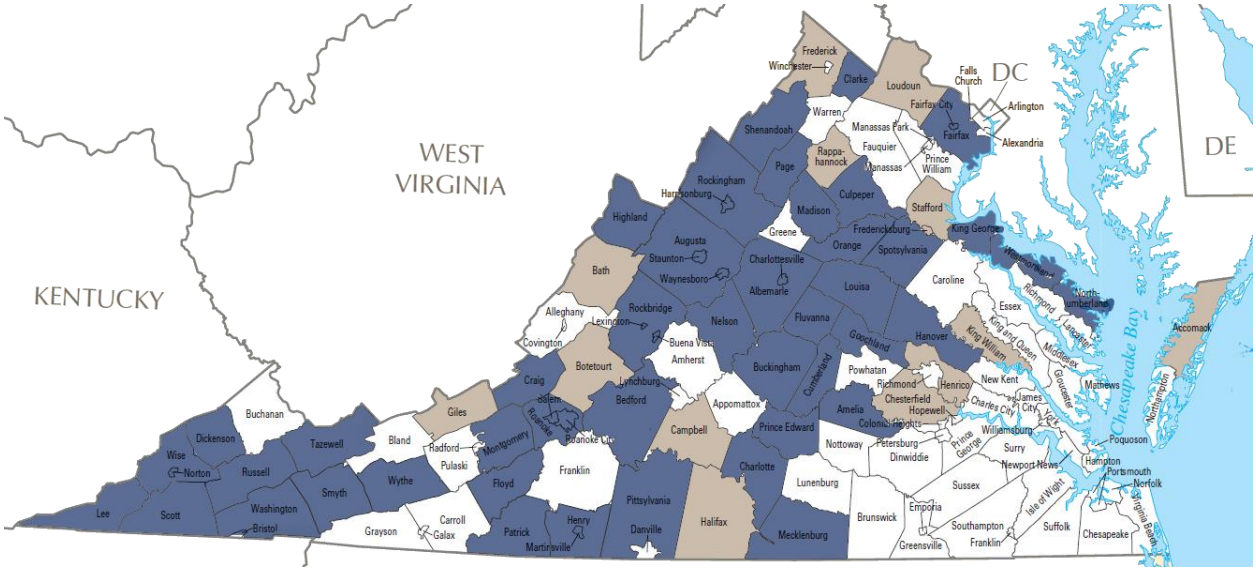

Figure 3.2 Map of counties represented by survey respondents. Blue indicates counties where surveys were completed; Beige indicates counties where surveys were sent but there was no response.

Table 3.3: Livestock producer characteristics among survey respondents enrolled in cost-share programs for livestock in Virginia

Socioeconomic Variables	**All Respondents (n=139)**
Age (years)	
25-44	16.3% (n=22)
45-64	51.1% (n=69)
65+	32.6% (n=44)
Gender	
Male	94.8% (n=128)
Female	5.2% (n=7)
Education	
Some high school and high school degree	27.8% (n=38)
Associates degree	14.6% (n=20)
Bachelor's degree	33.6% (n=46)
Graduate degree	24.1% (n=33)
Income	
Less than $50,000	18.0% (n=21)
$50,000 - $100,000	40.2% (n=47)
$100,000-$150,000	23.1% (n=27)
$150,000 and above	18.8% (n=22)
Production	
Primarily Cattle	73.7% (n=101)
Primarily Ruminants	8.8% (n=12)
Mixed Production	16.1% (n=22)
Other	0.14% (n=2)
Years Farming	
Average years farming	30.6 (n=135)
Acreage	
Average acreage used for production	330.0 (n=134)
Average acres of land forested	51.2 (n=128)
Primary Occupation	
Yes	36.8% (n=49)
No	63.2% (n=84)
Physiographic Region	
Mountains	61.8% (n=84)
Piedmont	32.4% (n=44)
Coastal	5.9% (n=8)

Wilcoxon-Signed Rank Test results indicate a statistically significant difference between respondent interest in thinning existing woodland for silvopasture and their interest in planting trees in pasture (**Error! Reference source not found.**). Thinning was ranked significantly higher as shown by the number of negative ranks for Planting. In general, the effects of different outcomes on respondent interest in thinning varied, but *Profit from Thinning* was significantly lower when compared to *Improve Health of Woodlot*, *Pasture Break*, and *Forester Assistance*, as shown by a consistent negative ranking when compared to other variables (

Table *3.5*). Regarding outcomes associated with planting, *Shade for Livestock* had a significantly larger effect than all other variables except *Cost-Share Assistance*. *Cost-Share Assistance*, in turn, was ranked significantly higher than *Environmental Payments*, *Profit from Timber*, and *Adequately Budgeted Time and Protection* (

Table *3.6*).

Table 3.4 Wilcoxon-Signed Rank Test results measuring the rankings of interest in planting trees and interest in thinning trees

Comparison variables	Categories	N	Significance
Interest in planting trees in a pasture - interest in thinning woodlot to establish silvopasture	Negative Ranks	78	.001
	Positive Ranks	24	
	Ties	37	

Table 3.5: Wilcoxon-Signed Rank Test measuring activator variables against one another for significance in ranked score

Categories	Comparison Variable	N	Significance
Improve Health of Woodlot	Profit from Thinning	108	.000[a]
	Pasture Break	105	.259[c]
	Forester Assistance	107	.362[c]
Profit from Thinning	Pasture Break	107	.000[b]
	Forester Assistance	107	.000[b]
Pasture Break	Forester Assistance	107	.893[c]

a. Positive rank
b. Negative rank
c. Ties

Table 3.6 Wilcoxon-Signed Rank Test measuring activator variables for interest in planting to create silvopasture against one another for significance in ranked score

Categories	Comparison Variable	N	Significance
Shade for Livestock	Environmental Payments	122	.008[a]
	Profit from Timber	120	.001[a]
	Cost-Share Assistance	120	.688[c]
	Adequately Budgeted Time and Protection	116	.000[a]
Environmental Payments	Profit from Timber	116	.359[c]
	Cost-Share Assistance	118	.001[b]
	Adequately Budgeted Time and Protection	111	.010[a]
Profit from Timber	Cost-Share Assistance	116	.000[b]
	Adequately Budgeted Time and Protection	111	.029[a]
Cost-Share Assistance	Adequately Budgeted Time and Protection	114	.000[a]

a. Positive Rank
b. Negative Rank
c. Ties

With respect to thinning, 77 producers responded with open-ended comments to help qualify their quantitative response on the Likert-type scale. Positive comments about thinning woodlands for silvopasture were coded and grouped into the following themes: shade for livestock, increased production and income on the farm, expanded pastures, and potential to improve land management (Table 3.7).

Table 3.7 Respondent introduced themes related to opportunities when thinning woodlots for silvopasture

Opportunities	Number and percent of respondents
Expand Pasture	15 (20%)
Improve Farm Management	14 (18%)
Shading for livestock	12 (16%)
Improve Forested Land	7 (9%)
Increase Production and Income	7 (9%)

For example, one respondent noted they would be interested, “if I can increase grazing area and cows. I also think, if managed, it can be good for the woods” while another respondent noted, “it’s mutually beneficial to the pasture, trees, and livestock – it just makes sense.” Commonly cited constraints were maintenance requirements, negative impact on trees, establishment costs, and a lack of suitable land (Table 3.8). One respondent commented that:

"cattle in woods will kill trees which will affect the timber harvest," and another respondent stated, "honestly – it's just another thing to manage at this point. Cattle are not my #1 income stream."

Table 3.8 Respondent introduced themes related to constraints of thinning woodlots for silvopasture

Constraints	Number and percent of respondents
Hard to maintain	6 (8%)
Negative Impact on trees	5 (7%)
Wildlife/environmental impact	4 (5%)
Cost of establishment and maintenance	2 (3%)
Land is not suitable	1 (>1%)
Quality of livestock would decrease	1 (>1%)

Seventy producers provided comments to qualify scaled responses regarding interest in planting. Of the most commonly cited opportunities that planting trees for silvopasture provided, shading for livestock was at the forefront (Table 3.9). Others included diversifying and expanding pasture, better land management, and increased diversity.

Table 3.9 Respondent introduced opportunities related to planting trees in a pasture to create silvopasture

Opportunities	Number and percent of respondents
Shading for livestock	16 (23%)
Diversify and Expand Pasture	4 (6%)
Better Land Management	3 (4%)
Increase diversity	2 (3%)

There were several comments about the opportunity presented from shade: "I would like for my animals to have more shade", "my livestock need more shade in summer and shelter throughout the year", and, "sheep seem to prefer having some trees for shade." In terms of constraints (Table 3.10), loss of pasture was common, "I have my pastures in fairly good shape. I'm reluctant to tinker with them too much" and "It will take land out of production, especially when planting trees until big enough to graze around." However, there were other difficulties, such as tree mortality, "I planted 200 trees in 2005 and another 200 in 2015 – very few survived

floods" and steep topography, "We already have shade in pasture. Topography is so steep that we have limited pasture already clear."

Table 3.10 Respondent introduced constraints related to planting trees in a pasture to create silvopasture

Constraints	Number and percent of respondents
Loss of Pasture/Production	14 (20%)
Time/Cost to Manage and Maintain	7 (10%)
Steep Topography	4 (6%)
High Mortality for Trees	4 (6%)

3.4 Discussion

This study focused on demographics, establishment preferences, and the effects of different outcomes on interests among livestock producers. Respondents in this study tended to be older, which generally aligns with the average age (59.1) years reported in Virginia's agricultural census (VDACS 2017). Age is generally considered to be related to agroforestry adoption (Matthew, et al. 1993), with younger respondents often reported as more inclined (Trozzo et al. 2014). This indicates that our study respondents might be less inclined than a younger sample population of livestock producers. Furthermore, higher income and education also are often cited as increasing the likelihood of agroforestry adoption (Featherstone and Goodwin 1993; Cooper and Jacobson 2009), but this was not explicitly measured in this study. Other demographic data were aligned relatively closely with census data (VDACS 2017), though there were some differences. For example, mean farm size differed from Virginia's average with the study average of 331 far exceeding the state value of 180. Disparities among census data and survey respondents may be related to our study population, which consisted of a set of cost-share enrollees in a government program who therefore may have more access to resources and experience than a typical Virginia landowner.

The study focused on two forms of silvopasture establishment (thinning a woodlot or planting trees in a pasture) and sought to test whether there are differences in the interest levels among livestock producers. Our results indicate most landowners prefer thinning to planting as a means for establishing silvopasture. This result has important implications given that over 15% of the land base owned by respondents is forested. Though this is not comparable to open pasture in terms of owned acres, the cumulative forest base is substantial among the respondents. Thinning seems to be the first choice for silvopasture establishment among livestock producers. The result addresses a gap in the literature regarding preferences for implementation, given past agroforestry research has instead generally focused on economic constraints and environmental impacts with respect to the general notion of silvopasture (Cubbage et al. 2012; Mayerfeld, et al. 2016; Morse, et al. 2018).

Regardless of whether a livestock producer prefers to thin their forest or plant trees in their field, or do both, little is known about precision management to effectively establish these practices in temperate setting such as Virginia. Fike et al. (2004) and Orefice and Carroll (2017), for example, offer important findings and recommendations. However, these studies and others focus exclusively on planting. Even then, calls are made to improve our understanding of management parameters related to tree protection, site preparation, damage mitigation and tree stress, among others, in open field silvopasture implementation. In terms of thinning, Walters (1939) provides recommendations for tree and grass symbiosis, but much remains to be researched from the stand point of silvicultural science.

In general, the evolving nature of silvopasture and its distinct forms of establishment are tied to the perception of risk. This is not uncommon in the field of agroforestry more generally (e.g., Trozzo et al. 2014). Pattanayak et al. (2003) framed several factors that affect agroforestry

adoption, one of which is risk. Four buffers were reported by the authors that are of importance when determining what would decrease the negative effects of risk perception. Factors included tenure, experience, extension, and membership. Along those lines, two potential outcomes stood out in this study relative to their effect on respondent interest: environmental performance and assistance/facilitating conditions.

For thinning, the two most highly significant factors were improving health of a woodlot and receiving assistance from a forester. This suggests livestock producers may feel more comfortable adopting thinning if environmental benefits were achieved that improve their land and overall operation. Jose (2009) conducted a review of environmental outputs related to agroforestry and suggested farmers and landowners valued environmental studies and their relationship in better understanding the practice. Further literature on environmental factors related to agroforestry adoption indicate landowners who value environmental benefits often are more likely to adopt (Current et al. 1995; Mantagnini and Nair 2004; Arbuckle 2009). Our results suggest environmental benefits may be a leading factor in the tendency to adopt silvopasture.

Forester assistance was highly significant when ranked against other activator variables and qualitative data showed some respondents desired to improve the health and productivity of their forested land through silvopasture. Access to technical assistance could help livestock producers accomplish this goal. Furthermore, this suggests thinning a woodlot to create a silvopasture has a higher potential for adoption if livestock producers have more contact with forestry extension agents. This aligns with the findings of Strong and Jacobson (2005) who found technical assistance to be a potential constraint and Pattanayak et al. (2003) who found that risk and uncertainty were buffered by extension services. It appears outreach and education

may need to rethink its emphasis on economics specific to the agroforestry practice and focus more on environmental management attributes to support success in other forms of land use and production. Nevertheless, healthy and productive trees in agroforestry systems can enhance overall yield, thus diversifying financial opportunities and potentially boosting returns while also meeting environmental objectives (Lindgren and Sullivan 2014).

Outcomes that significantly influenced interest among respondents in terms of planting silvopastures were similar to those that affected thinning interests, namely environmental performance and assistance-related factors. Yet, the nature of the benefits differed. Shading for livestock had the largest affect, which aligns with studies in the silvopasture adoption literature outlining benefits and goals for livestock comfort and protection (Fike et al. 2004; Cubbage et al. 2012; Mayerfeld et al. 2016). Environmental payments also ranked highly, which is a more explicit suggestion that environmental outputs of silvopasture could increase a landowner's interest. Finally, cost-share assistance also had a greater effect on interest when compared to other economic or temporal factors studied.

The effectiveness of cost-share is debated in conservation agriculture literature, but it has been proven to help bolster environmental conservation practices, such as combating soil erosion, improving water quality, and producing on marginal or lower-quality land (Claassen et al. 2008; Manley and Mathias 2017). If silvopasture exposure and extension training were to increase, adoption of the practice would likely rise. Since livestock producers in this study valued both environmental payments and cost-share assistance, cost-share and service provider assistance can act as a buffer to the perceived risk of planting trees in pastures while also assisting producers in environmental gains.

Literature on agroforestry adoption more broadly, but silvopasture more specifically, often points to economic barriers as the single most critical aspect or driver of adoption (Cubbage, et al. 2012; Strong and Jacobson 2016). Results in this study suggest producers may be more inclined to focus on environmental benefits, which help improve their livestock operation and its associated financial returns rather than primarily weighing how these systems may directly affect their bottom line in terms of additional salable tree products. Similarly, it seems livestock producers are generally more inclined to target forests for thinning, though some showed interest in planting as well. Either way, those who use assistance programs require and seek assistance. This may not be easily accomplished, however. Due to extension agent awareness of silvopasture, as well as best management practices and standard strategies, silvopasture may continue to be low until these practices are further investigated.

3.5 Conclusion

Interest levels in thinning and planting to establish silvopasture varied among livestock producers in this study, but there was a clear trend towards thinning forests. Respondents were more inclined to have a greater interest with respect to environmental performances. Furthermore, they consistently reported that their interest would be most affected when resources associated values, such as forester or cost-share assistance, were included. This highlights that there are complexities to livestock producer adoption of silvopasture beyond simple financial cost-benefits. This also could have further implications regarding how extension agents and technical service providers manage outreach and technical transfer.

Silvopasture itself is an important practice that can assist landowners and livestock producers alike in terms of properly managing aspects of their operation. If a better understanding of extension and outreach drove silvopasture adoption, this could provide

numerous benefits to land and livestock. Furthermore, it could diversify agricultural and forestry practices in the U.S. and internationally that affect our food, economies, relationships to the land, and best practices for each system. In order to better our understanding of silvopasture, more research is needed, both regionally and nationally, to help inform outreach and extension that meet the needs of farmers, landowners, and livestock producers who are inclined to adopt silvopasture.

Chapter 4 Is interest in silvopasture related more to a producer's operational characteristics or management beliefs?

Abstract

Silvopasture is an agroforestry practice that integrates trees, forage, and livestock. It is a way for livestock producers to diversify management activities in the same land unit, while increasing on-farm environmental services. In terms of understanding interests in agroforestry practices such as silvopasture, some literature indicates operational characteristics (e.g., size) are most salient, whereas others report that belief factors like land use values and tradition are leading considerations. To study whether operation type or producer beliefs correlate with interest in silvopasture, we surveyed all 307 livestock producers enrolled in seven livestock limitation cost-share programs with the Natural Resource Conservation Service in the state of Virginia (USA). One hundred and thirty-nine responded (45%). Interest in silvopasture was measured among all respondents. Multivariate cluster analysis was used to group respondents into two independent classification sets. The first classification set was determined using a two-step cluster procedure that included operational variables (e.g., head of livestock). The second classification set was created using a K-means cluster procedure that included belief variables (e.g., perspective on planting trees on farms). We tested for statistically significant differences in silvopasture interest between respondent classifications in each of the two independent respondent clusters. Results indicate that silvopasture interest differs significantly between respondent classifications in the beliefs cluster, but not between respondent classifications in the operational cluster. Cross-tabulations of the two independent classification sets (operational

cluster by beliefs cluster) resulted in no discernable correlation. Literature suggest both operational characteristics and producer beliefs may affect adoption, but levels of interest also vary broadly. Results from this study suggest producer perspectives matter more than the nature of their operation, which has important implications in terms of scaling agroforestry practices.

4.1 Introduction

Silvopasture is an agroforestry land use that intentionally combines trees and livestock in the same management unit (Garrett et al. 2004). These polyculture systems form intensive systems of animal husbandry, forestry practices, and forage agronomy (Sharrow et al. 2009). Silvopasture management requires complex planning and forethought, because it can be costly, damage trees, alter native habitat, and reduce forage, which can lead to system failure (NRCS 2011). Silvopasture adoption is an area of research and technical transfer that is gaining momentum in the United States (US) (NASS 2012; MacFarland 2015). Agroforestry adoption studies generally focus on the role of technical assistance, as well as time, effort, and producer norms (Shrestha et al. 2004; Calle et al. 2009; Fike et al. 2014). Several broad themes have emerged that align with research specifically pertaining to silvopasture adoption: a) the ways in which acreage and other operational considerations relate to interest and adoption; and b) how beliefs affect adoption.

Literature focused on the operational side of adoption provides many examples that drive livestock producer interest. In Pattanayak et al. (2003), biophysical interactions and landowner characteristics are highlighted as key predicators of behavior. Biophysical factors, such as soil, slope, plot size, and irrigation often were found to be statistically significant in adoption studies but varied greatly with respect to whether those factors positively or negatively associate with interest. However, other studies have indicated that land tenure can positively affect adoption (Mercer 2004; Arbuckle et al. 2009). With respect to silvopasture, Warren et al. (2012) focused on operational factors, such a size and type of farm, and found small-scale farmers were more likely to see the economic benefits of silvopasture. However, other studies found little correlation between operational factors (e.g., size) and interest/adoption of agroforestry

(Alavalapati et al. 2004; Perez 2006). Another key indicator studied in the adoption literature is farmer demographics. Age, gender, and income have been found to have varying degrees of importance with respect to adoption (Matthews et al. 1993; Pattanayak et al. 2003; Strong and Jacobson 2005). Primary occupation represents a gap in the adoption literature and research is needed to understand its role in landowner operations.

Pattanayak et al. (2003) addressed the issues of beliefs and attitudes in the agroforestry adoption literature yet stated those variables can be hard to measure. Often, these are not explicitly stated but can encompass perceptions of socioeconomic factors and environmental outputs. In their theoretical framework, Pattanayak et al. (2003) posit that preferences such as age, gender, or socioeconomics act as proxies for those belief variables. Yet, research on beliefs is relatively scarce. Meijer et al. (2016) measured beliefs as a factor in agroforestry adoption in Malawi and defined them as the perspectives a person has which leads to a particular, pre-defined course of action or outcome. This study assessed how beliefs impact the positive or negative correlation between farmers and tree planting. Somewhat similarly, Shrestha et al. (2004) suggested concepts of land stewardship and support for environmental benefits were considered common opportunities for landowners in south central Florida, yet environmental policy was viewed as a constraint.

Income diversification in agroforestry often is noted as an economic benefit (Borremans et al. 2016), but long-term investments and associated risks likewise are reported as a constraint (Trozzo et al. 2014). Other studies have suggested that cultural, aesthetic, and convenience factors often override certain financial considerations (Matthews et al. 1993; Ryan et al. 2003; Strong and Jacobson 2005; Arbuckle et al. 2009; Barbieri and Valdivia 2010). In the agricultural literature more generally, technology adoption among livestock producers appears to follow no

trend; many studies cite knowledge of the practice and identity as factors influencing livestock producer behavior (Winsten et al. 2010; McCutcheon et al. 2015). When combined, these factors embody a broad range of indicators related to beliefs, but many have varying degrees of importance in the literature. Nevertheless, they are critical to understanding many of the social and psychological factors that affect adoption.

This study contributes to the silvopasture adoption literature as the question of whether operation or beliefs matter more. In Virginia, livestock production is a substantial agricultural enterprise, with the beef cattle industry alone being the state's largest agricultural employer providing more than 37,000 jobs. Frey et al. (2016) cited Virginia as a unique area of overlap between the Southeast, Mid-Atlantic, and Appalachian regions and, therefore, an important location for silvopasture research.

We studied interest in silvopasture among livestock producers in Virginia and analyzed the relationship between interest and operation, and interest and beliefs using two independent respondent classifications. Our hypotheses were that silvopasture interest would not differ between operational classifications representing respondent differences in size of operation, type of livestock, etc. or belief-based classifications representing respondent differences in perspectives known to affect agroforestry.

4.2 Methods

Three hundred and seven livestock producers enrolled in seven NRCS livestock initiatives in Virginia were mailed a survey instrument designed to measure their interest in silvopasture and a battery of operational and belief-related variables. Enrollee contact data were accessed through the Freedom of Information Act (FOIA). An expert panel consisting of livestock producers, farm owners, and forestry and conservation agency and extension personnel

evaluated the instrument and provided feedback based on common trends and experiences among livestock producers, as well as survey item comprehension. Once revised, the survey was administered following Dillman's Tailored Design Method (Dillman et al. 2009).

A pre-notification letter was sent informing the population of an impending questionnaire and describing the study and parameters for participation. The survey instrument was delivered ten days later with a cover letter and pre-addressed stamped envelope. Return of the survey by the respondent implied consent. Following the initial mailing, a reminder postcard was mailed two weeks later to non-respondents. A final cover letter, survey, and pre-addressed stamped envelope were sent a week later.

Following a brief description of silvopasture, respondents were asked to report their general interest in the practice on a 1-5 Likert-scale spanning from: 1 = "I am not interested, 3 = "I am interested" and 5 = "I am very interested". Frequencies and measures of central tendency were computed for the response set and statements and questions on operational and belief related variables also were measured. Respondents were asked to report the total acres in production, the type and number of livestock they manage, and if livestock production is their primary occupation. The operational classification was comprised of those variables. They also were asked to respond to a set of 15 Likert-type items designed to measure their beliefs pertaining to a set of financial, environmental, and social items related to silvopasture production. The beliefs classification consisted of those items.

A two-step statistical clustering procedure was used to group respondents into classifications based on parametric and non-parametric operational variables. This procedure groups independent observations into clusters using multiple measurements, the overall variation of which was used to segment producer respondents into statistically differentiated

classifications. Silhouette of cohesion depicts the strength of the cluster result. An acceptable cohesion score on a scale of 0-1 is anything over 0.7. A relatively even distribution of observations across classifications also is desirable, but not necessary.

Belief variables were grouped into principal components. Variables in each group were summed and averaged to generate summated mean scores that reflect an underlying latent construct. Exploratory Factor Analysis (EFA) was used to group the 15 belief measures into separate factors. EFA is a multivariate statistical analysis used to factor variables with similar relationships in terms of the overall variance explained (Gorsuch 1974). This improves the manageability of a large item dataset by identifying a smaller number of concepts represented by a larger battery of single latent psychosocial measures such as beliefs about an innovation or behavioral change.

Principal components were selected as the EFA procedure and factoring was based on varimax rotation and Eigen-values greater than 1. The Kaiser Meyer Olkin (KMO) test was used to determine if variance in a dataset is the cause of underlying factors and Bartlett's test of sphericity was used to determine if independent items are 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 (<0.05) indicates relatability between independent items.

A k-means cluster statistical clustering procedure was used to group respondents into independent classifications using summated beliefs-based construct means determined through EFA. Similar to two-step clustering, k-means groups independent observations into clusters using multiple variables, but differently 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 that have been determined to measure an underlying construct can be assumed to have an underlying parametric continuum which more accurately distinguishes between respondents (Spector 1992; DeVellis 2003). Summated mean scores are constructed from latent variables, but because they reflect a scaled or standardized latent observation, they represent an average rather than a single ordered or nominal variable (Diday 1976). A one-way analysis of variance was computed for each mean score and the beliefs classification and significance results are displayed.

The two independent classification sets determined are herein referred to as *operational* and *beliefs*. Variations in the data used to create these classifications were evaluated for respondents grouped separately for both classifications. Trends in the data were used to create descriptive titles for each classification set. These typological classifications were used as factoring variables in two non-parametric independent samples tests for statistically significant differences in silvopasture interest.

The first test for statistical significance used operational classifications as the factoring variable and the second test used classifications based on beliefs. Kruskal-Wallis non-parametric test was conducted, and rank sum scores are reported, as are significant differences and mean scores to depict central tendencies. Because each respondent was independently classified in the two cluster results, both were cross tabulated to study the distribution of classifications across all respondents. Demographic and operational frequency data also are presented to characterize respondent classifications.

4.3 Results

Three-hundred and seven surveys were mailed and 139 returned for a response rate of 45.3%. Survey respondents were 94.8% male and 83.7% were over the age of 45. Most had a

bachelor's degree or higher and 63.2% did not work with livestock as their primary occupation. Producers worked primarily with cattle (73.7%), but 16.1% claimed a mixed production system, which could be any combination of poultry, cattle, or other stock such as sheep. Most survey respondents were concentrated in the mountainous region of the state (61.8%), but producers in the piedmont and coastal plain also responded (32.4% and 5.9%, respectively).

Silvopasture interest was distributed across all Likert-type scale response options, but respondents most frequently reported moderate interest in silvopasture (Table 4.1). When taken together with those reporting higher levels, more than 60% of the livestock producer respondents in this study were at least interested in silvopasture. Just over a third of the respondents were not interested.

Table 4.1 Respondent's baseline interest level in silvopasture

			Interest Level increases →				
			1	2	3	4	5
μ	n	SD	n=19	n=25	n=47	n=19	n=19
2.95	129	1.24	(14.7%)	(19.4%)	(36.4%)	(14.7%)	(14.7%)

μ = mean; n= number of respondents; SD = standard deviation

The two-step cluster procedure resulted in four independent classifications (Table 4.2). These classifications differed based on operational characteristics (e.g., number of livestock, primary occupation, etc.) and were interpreted to generate descriptive titles for each: *full time, mid-size, cattle producer*; *full time, large scale, cattle producer*; *part time, small-scale producer with mixed livestock production*; and *part time, mid-size, cattle producer*. In general, these classifications reflect operational variation among livestock producers, highlighting distinctions between full-time and part-time, cattle-dominated and mixed production (e.g., small ruminants, poultry), and small-, medium-, and large-scale operations.

Table 4.2 Two-step cluster results for operational classification based on typical production characteristics

	Typologies			
	Full time, mid-size, cattle producer (n=30)	Full time, large scale, cattle producer (n=20)	Part time, small scale producer with mixed livestock production (n=24)	Part time, mid-size cattle producer (n=54)
Farming as Primary Occupation	**100%**	**90%**	0%	0%
Cattle as Primary Livestock	100%	60%	**45.8%**	100%
Average Number of Livestock	115	611	66	**81**
Average Acres of Production	287.77	1037.85	66.04	203.80

Silhouette measure of cohesion and separation = .7; overall predictor importance order: primary occupation, type of livestock, number of livestock, and acres of production; bolded numbers signify top predictor importance within cluster type

Full time, mid-size, cattle producer are respondents that identified livestock production as their primary occupation and primarily managed cattle. On average, they owned 287 acres and an average head of 114 cattle. Almost all *full time, large-scale, cattle producer* managed livestock as a primary occupation, and cattle were the dominant livestock type. Their average acreage and head of livestock were highest among all operational types, at 1,037 acres and 610 cattle.

Part time, small-scale producer with mixed livestock production were the only respondent type not dominated by cattle production. Just over half primarily managed other small ruminants, poultry, or some combination of those alongside cattle. Farming was not their primary occupation and their average acreage and number of livestock were relatively small, with an average of 66 acres and 65 head. *Part time, mid-size, cattle producer* had a slightly higher average acreage and operational scale when compared to their mixed production part-time counterparts, with 203 acres and 80 head of cattle.

EFA analysis resulted in four factors from the 15 usable survey items: Financial Focus (3 items), Amenity and Tradition (4 items), Agroforestry Acceptance (5 items), and Farm Management Beliefs (3 items) (Table 4.3). The KMO result in this study was 0.82 and sphericity result was <0.00. Component factors were based on underlying concepts in the grouped survey questions (Table 4.4). K-means clustering using the four summated means generated from EFA

components were computed and, similar to the operational typologies, evaluated for trends between the independent classifications. An analysis of variance was computed for these means and significance results are displayed. Descriptive titles were generated for the independent beliefs classifications: *middle of the road*; *highly invested*; *finance and tradition oriented*; and *farm management conscious* (

Table *4.5*).

Table 4.3 Rotated Component Matrix for EFA Factor Loadings of survey item responses among livestock producers in Virginia

Survey Items	Financial Focus	Amenity and Tradition	Agroforestry Acceptance	Farm Management Beliefs
No equipment needed	-.021	.094	**.923**	.235
No hindrance to livestock productivity	.086	.031	**.917**	.162
No risk	-.024	.085	**.888**	.228
Receive cost-share assistance	.011	.068	**.878**	.151
See a successful example	.061	-.008	**.684**	.333
Importance of Agricultural Tradition	.085	**.816**	.102	-.026
Importance of Love of Farming	-.086	**.786**	.084	.064
Importance of Maintaining VA's Agriculture Economy	.369	**.726**	.072	-.007
Importance of Pride in Producing Food	.281	**.634**	-.048	.100
Importance of Financial Investment	**.846**	.116	.002	.034
Importance of generating Personal Income	**.830**	.051	.092	.063
Importance of keeping Livestock Markets Competitive	**.693**	.342	-.027	-.194
Feelings thinning forest to graze livestock	-.044	.230	.273	**.780**
Feelings managing tree, livestock, and forage together	.120	.045	.389	**.765**
Feelings planting trees in pasture	-.080	-.101	.225	**.688**

Fifteen variables grouped into four topics. Total variance explained was 70.71%. KMO measure of sampling adequacy was 0.818. Bartlett's test of sphericity was 0.00. Bold items signify grouped variables.

Table 4.4 Survey questions and their corresponding belief measures

Component Constructs	Survey questions
	How important are the following to you when it comes to livestock production?
Financial Focus	Generating Personal Income Keeping Livestock Markets Competitive As a Financial Investment
Amenity and Tradition	Sustaining Virginia's Agricultural Economy Maintaining a Farming Tradition Love of Farming Pride in Producing and Selling Food
	How much would each of these increase your interest in silvopasture?
Agroforestry Acceptance	Seeing a successful example Receiving cost-share assistance Not hindering livestock productivity Implement without equipment Implement with no risk
	How do you feel about the following?
Farm Management Beliefs	Planting trees in a pasture Thinning a forest to graze livestock Managing trees, livestock, and forage together

Table 4.5 Interpretation of means to create K-means cluster from Exploratory Factor Analysis and significance results from analysis of variance test between groups

	Typologies			
	Agroforestry Acceptance	**Amenity and Tradition**	**Financial Focus**	**Farm Management Beliefs**
Middle of the road (n=29)	3.21	3.31	3.17	1.85
Highly invested (n=48)	4.50	3.74	3.56	2.50
Finance and tradition oriented (n=25)	1.78	3.40	3.09	1.85
Farm management conscious (n=32)	4.06	2.95	2.20	2.43
Significance of variance between groups	**.000**	**.000**	**.000**	**.000**

Middle of the road did not have a particularly high or low mean rank for any of the summated mean variables, indicating a more reserved set of respondents. *Highly invested* was the largest group with the highest mean construct scores across all types. *Finance and tradition oriented* had the highest summated mean scores as financial and tradition-oriented variables. *Farm management conscious* represents those who had a high mean score for agroforestry acceptance, as well as their beliefs about farm management.

There were no statistically significant differences between silvopasture interest across operational classifications (Table 4.6). Rank sum scores indicate *part time, small-scale producer with mixed livestock production* had the highest rank sum score for interest at 73.27 and the *full time, mid-size, cattle producer* had the lowest at 53.22. On the other hand, silvopasture interest differed significantly between beliefs-based classifications (Table 4.7). *Highly invested* had the highest rank sum scores (86.95) and *finance and tradition oriented* had the lowest (36.38). Cross tabulation showing the percentage breakdown of each typology group among the other typology groups indicate no pattern in respondents between the two classifications (Table 4.8).

Table 4.6 Operational classifications in an independent samples analysis to measure silvopasture interest

	Operational Classifications				
	Full time, mid-size, cattle producer	Full time, large scale, cattle producer	Part time, small scale producer with mixed livestock production	Part time, mid-size, cattle producer	Sig.
	Rank Sum Scores (Mean)				
Silvopasture Interest	53.22[a] (1.35)	66.48[a] (3.05)	73.27[a] (3.30)	66.14[a] (2.98)	.209

Rank sums with the same letter are not significantly different

Table 4.7 Belief classifications in an independent samples analysis to measure silvopasture interest

	Belief Classifications				
	Middle of the road	Highly invested	Finance and tradition oriented	Farm management conscious	Sig.
	Rank Sum Scores (Mean)				
Silvopasture Interest	47.78[a] (2.34)	86.95[b] (3.69)	36.38[c] (1.76)	80.52[d] (3.39)	.000

Rank sums with the different letters are significantly different according to Pairwise Comparisons

Table 4.8 Crosstabulation of operational and belief classifications

	Beliefs Classifications			
Operational Classifications	Middle of the Road (n=26)	Highly Invested (n=46)	Finance and Tradition Oriented (n=24)	Farm Management Conscious (n=31)
Full time, mid-size, cattle producer (n=29)	5.5%	6.3%	7.1%	3.9%
Full time, large scale, cattle producer (n=20)	2.4%	7.1%	3.1%	3.1%
Part time, small scale producer, mixed production (n=24)	3.9%	6.3%	2.4%	6.3%
Part time, mid-size cattle producer (n=54)	8.7%	16.5%	6.3%	11.0%

4.4 Discussion

Interest in silvopasture was relatively evenly distributed among livestock producer respondents. Mean response was 2.1 on a scale of 1-5, indicating little interest overall. However, just over a third ranked their interest as a 3, and more than 27% ranked their interest a four or higher. Similar to other agroforestry adoption studies, interest is not highly skewed. Since survey respondents were exclusively livestock producers, this furthers the understanding of whether and to what extent farmers specializing in livestock production are interested in adopting agroforestry practices. Nevertheless, as in previous adoption studies, interest levels and reasoning vary.

Previous studies suggest that operational characteristics are the chief factors (e.g., Strong and Jacobson 2005; Arbuckle et al. 2009), while others argue that beliefs are most influential (e.g., Pattanayak 2003; Ryan et al. 2003; Mercer 2004). Pattanayak et al (2003) discovered that biophysical characteristics played a role in agroforestry adoption. Furthermore, the role of land tenure on adoption is shown to be variable, occasionally it is positively correlated and then negatively at other times (Pattanayak et al. 2003, Mercer 2004). Finally, the scale of production is hypothesized to make a difference in silvopasture adoption (Frey et al. 2012; Frey and Comer 2018) Our study tested this proposition and found that interest in silvopasture does not differ between producer classifications based on operational variables such farm acreage, type and number of livestock owned, and whether respondents were full-time producers. On the other hand, we found that silvopasture interests differed across respondent classifications based on management beliefs, and we observed no distinct trend in the relationship between operational or beliefs classifications.

Our finding that interest in silvopasture differs significantly across producers' beliefs, but not their operation, and that there is no discernible relationship between independent

classifications along these lines aligns with some lines of reasoning in the agroforestry adoption literature. Matthews et al. (1993) and Ryan et al. (2003) argued that culture and identity are strong indicators of interest in agroforestry. Furthermore, concepts of income diversification and environmental benefits have been reported to increase interest (Current et al. 1995; Shrestha et al. 2004). Nevertheless, investments, time, and effort often are prohibitive, but can be overcome by attitudinal alignment which has been observed among large and small producers (Current et al. 1995; Trozzo et al. 2014; Borremans et al. 2016).

Our results indicate that more important to understanding livestock producer interest in silvopasture are their beliefs rather than the type and size of their livestock operation. This has important implications regarding future adoption research and extension programming. For one, findings suggest that interests are not necessarily a product of a big or small livestock operation, or one that manages single or multiple species. This means the interest in silvopasture adoption may be the same across all operations and what matters more is the nature of a producer's beliefs.

Beliefs in this study can be characterized by outputs from the sum rank score for each classification. Results suggest variation among groups may play a role in the types and inclinations of potential adopters. For example, *highly invested* producers had the highest sum rank score, which suggests they represent innovator and early adopters characterized in diffusion literature (Rogers 2003). Furthermore, *middle of the road* respondents may constitute a different set of producers who are less inclined to adopt in the short-term because they have no strong perspective one way or the other. Finally, *finance and tradition oriented* and *farm management conscious* producers have clear perspectives that tend to prohibit high levels of interest in silvopasture, which may play a substantial role in the likelihood and timing of adoption.

Trends in the literature and anecdotal evidence, along with general assumptions about scale in agricultural production suggest that a large-scale cattle producer might be solely driven by finances and less inclined to diversify their operation using silvopasture. The opposite could be posited for small-scale goat farmers. Yet our findings indicate it is instead the beliefs that seem to matter more. This gives a more complex view of livestock producers, but these results indicate that they are not concerned with a singular component of their farm. Rather, it might be that they value multiple factors simultaneously.

4.5 Conclusion

Silvopasture is an agroforestry practice that intentionally combines trees, livestock, and forage in the same management unit (Merwin 1997; Gold and Garrett 2009). Livestock producers and stakeholders that seek to build resilient agricultural systems are on the rise and silvopasture is at the forefront of this movement. Those that invest in promoting these systems would benefit from understanding how livestock producers perceive this practice and the nature of their interest. Overall adoption is generally low, but the production and environmental benefits of silvopasture are clear. Efforts to continue the growth of sustainable agroecological farms and shape policies and outreach strategies to that end depend on effective communication and comprehension of the broad spectrum of producer perspectives and beliefs.

The findings of this study indicate that beliefs matter more than the nature of an operation in terms of interest in silvopasture. This is an important insight for policymakers, extension agents, research institutions, and producer organizations. Livestock producers not only think objectively about their production and the potential role of silvopasture but also rely on their own values and beliefs to make decisions. Those producers whose beliefs align with strong leanings toward interest are likely to be found across a variety of organizations and networks servicing

various operational structures and functions. In that regard, our findings contribute useful insight into the literature pertaining to silvopasture adoption and agroforestry acceptance more generally.

Resilient agricultural practices such as silvopasture are increasingly considered essential for sustainable food and fiber production strategies. Efforts to position silvopasture as an agroecological practice that balances farm output and environmental services are growing among production and conservation stakeholders. These advocates see the practice as a means for diversifying agricultural landscapes for the betterment of humans and the planet. The global community depends on healthy and productive environments and silvopasture is seen as a solution that can address environmental problems without compromising production. Interest in silvopasture exists among large and small producers who manage all forms of livestock as a part- or full-time profession. Their beliefs, on the other hand, correlate with different interest levels, which implies perspectives will matter more in the trajectory of future silvopasture adoption.

Chapter 5 Conclusion

5.1 Summary

The first objective of this study was to understand livestock producers' interest in two forms of silvopasture establishment: a) thinning trees in woodlots and b) planting trees in pasture. Furthermore, we measured how hypothetical benefits affect their interest in both forms. We used a Wilcoxon Signed Rank Test to test for a statistical difference in levels of interest in thinning woodlots and planting trees in pastures. We used Wilcoxon-Signed Rank Tests to test for differences in the extent to which benefits increase respondent interest. For thinning, the effects of environmental factors (improving health of the woodlot and pastures getting a break) and forester assistance were significantly higher. For planting, shading for livestock and cost-share assistance was significantly higher.

The second objective was to study whether livestock producer interest different according to their operation or their belief. Results indicated that silvopasture interest varied, but 60% of the sample population were at least interested. Two-step cluster analysis classified respondents into four groups based on their operations; EFA and k-means clustering of summated means classified respondents into four groups based on their beliefs. Independent samples analysis for each classification set revealed that there were no statistically significant differences in silvopasture interests among operational classifications. There were statistically significant differences in silvopasture interest among beliefs-based groupings, indicating that operations matter less and attitudes and beliefs on the practice more.

5.2 Conclusion

Considering the increase in outreach and extension for both agroforestry and silvopasture (Orefice and Carroll 2017), it is important to understand the preferences among potential

adopters. Livestock producers and their variable interests in different forms of silvopasture implementation can provide natural resource and forestry extension agents with a better understanding of needs. Results suggest that thinning a woodlot for silvopasture is preferred by livestock producers because of environmental benefits and potential forestry-related assistance The finding lays out a potential pathway for outreach to diversify management techniques and increase silvopasture adoption, which aligns with theoretical concepts and previous literature on adoption (Pattanayak et al. 2003; Barlow 2011; Lindgren and Sullivan 2014).

Gaining a deeper understanding of the different considerations among livestock producers is essential to furthering our understanding adoption of silvopasture. Clustering techniques generated two classification sets for all respondents: an operational set and a beliefs-based set. Results suggest that operational considerations do not beget an interest in silvopasture, whereas beliefs do. In light of previous research on operational considerations and the state of literature on agroforestry adoption, this study highlights an important finding: livestock producer beliefs are more important than the type and size of production.

5.3 Recommendations for Future Research

This research highlighted several important considerations when understanding silvopasture adoption. The type of silvopasture implementation (e.g., thinning or planting) matters among livestock producers but this could vary regionally where landowner types and policies and climates differ. Furthermore, the general inclination of livestock producers in this study to value environmental outputs and assistance-related factors highlights the need for more explicit studies on each. The implication that this study had in terms of understanding risk and uncertainty, as theorized by Pattanayak et al (2003) and Trozzo et al. (2014), also indicates that

agroforestry adoption literature needs to focus on the types and nature of considerations that impact risk.

Operational and beliefs-based classifications were useful in understanding what matters most to the interest of a livestock producer. The results indicate that beliefs significantly relate to silvopasture interest, which aligns with several agroforestry adoption studies on socioeconomics, demographics, identity, and attitudes (Current et al. 1995; Loomis et al 2000; Ryan et al. 2003; Mongtagnini and Nair 2004; Montambault and Alavalapati 2005). However, role of operations (e.g., land tenure) in agroforestry necessitates that further research related to these dynamics.

Accompanying these studies, additional research should explore other populations interested in silvopasture. Adoption studies based on the point-of-view of agriculture and forestry extension agents could provide additional useful insight. Finally, similar studies on livestock producers and silvopasture would be beneficial in different regions of the U.S., as spatial variation has been around as a critical piece in terms of silvopasture interest (Frey et al. 2016).

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Appendix

Appendix A. Survey Cover Letter

Forest Resources and Environmental Conservation
310 West Campus Drive
Blacksburg, Virginia 24061
P: (540) 231-5483
frec@vt.edu

Recipient
Address
City, State, Zip

Greetings!

I'm writing to ask for your help with a Virginia Tech student project that wants to know what you think about silvopasture. If you haven't heard of it before, silvopasture is the practice of managing trees and livestock together in the same place. My name is Delie Wilkens and I am a grad student in the Department of Forest Resources and Environmental Conservation. This project also involves Virginia Cooperative Extension. We want to know what livestock producers in Virginia think about silvopasture. Whether you think it is a good or bad idea, we'd like to hear your thoughts, so we can have an honest conversation about what producers in the state think about the practice.

Your responses to this **very** short survey will inform extension outreach and programs. You have been invited to participate because you have recently participated or are currently participating in a livestock-related program offered by the Natural Resource Conservation Service. Please understand that this survey is voluntary and your responses will remain confidential, but the overall findings may be published. Your identifiable data will be kept confidential by the researchers and stored securely, and no identifiable data will be included in publications and presentations. This survey should take 10-12 minutes to complete. By sending in the survey, you are indicating your consent to participate in this study. For questions about how you are protected, please contact me, or email the Virginia Tech Institutional Review Board at irb@vt.edu or call them at (540) 231-3732.

If you have any questions, please contact me at (540) 250-6314 or wilkensp@vt.edu. This project and its goals depend on the generous participation of people like you. Rather than see it as a chore, we hope you'll enjoy the opportunity to voice your thoughts and opinions. We look forward to hearing from you!

Sincerely,

Philadelphia Wilkens
Graduate Student, Virginia Tech
wilkensp@vt.edu
540-250-6314

John Munsell
Virginia Cooperative Extension

Appendix B. Survey Instrument

VIRGINIA TECH

Virginia Cooperative Extension
Virginia Tech • Virginia State University

Trees and Livestock

What do you think?

A Short Survey for Virginia Livestock Producers

What do you think about silvopasture (combining trees and livestock and managing them together)? Whether you think it is a good idea, bad idea, have yet to form a solid opinion about it, or have never heard of it, your responses will help Virginians have an honest conversation about the practice. The survey is short (4 pages, including an illustration) and should take no more than 10 to 12 minutes. Your responses will remain confidential and we would be happy to send you a general summary of the results if you enclose your name and address.

1. Please indicate the type(s) of livestock you own/manage: **(check all that apply)**

   ☐ Cattle ☐Sheep ☐Goats
   ☐ Hogs ☐Chickens ☐Others_____

   If you do not own/manage livestock, please skip ahead to question 15 on the back page

2. How many head of livestock do you currently own/manage?
   (if you own/manage more than one type, please specify the number for each type)

   _____

3. How many acres of land do you work for the purposes of livestock production? _____ **Acres**

4. Is livestock production your primary occupation? ☐ Yes ☐ No

5. Are you the primary decision-maker for your land/livestock? ☐ Yes ☐ No

6. How important are the following to you when it comes to livestock production?

Outcomes	Not at all important	Somewhat Important	Important	Extremely important
Sustaining Virginia's Agricultural Economy	1	2	3	4
Maintaining a Farming Tradition	1	2	3	4
Love of Farming	1	2	3	4
Pride in Producing and Selling Food	1	2	3	4
Food Source for Family	1	2	3	4
Generating Personal Income	1	2	3	4
Keeping Livestock Markets Competitive	1	2	3	4
As a Financial Investment	1	2	3	4

7. How many years have you been farming or working with livestock? _____ **Years**

8. How many acres of land do you own? _____ **Acres** ☐ I don't own land

9. How many acres do you lease for production? _____**Acres** ☐ I don't lease land

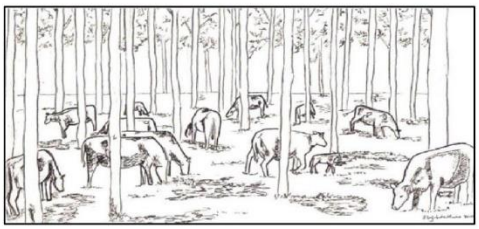
10. How many generations has your family raised livestock?

☐ I am the first generation ☐ 2 generations ☐ 3 generations ☐ 4 or more generations

11. Do you plan to keep raising livestock over the next 5 years? ☐ Yes ☐ No ☐ Don't Know

---

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.



12. If there are woodlands next to the pastures you own/lease, would you be interested in thinning out (**not** clear-cutting) trees on all or part of them if it could increase space for grazing (basically transform the woodlot into silvopasture)? *skip to question 13 if woods are not adjacent to your operation*

Interest level increases from left to right →

I am not interested		I am interested		I am very interested
1	**2**	**3**	**4**	**5**

In a few words, please let us know why you feel this way *(please skip if you don't care to share)*

_____

_____

Would any of the following increase your interest and, if so, how much?

The health and productivity of the woodlot would improve: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

✓ I would make a profit from the thinning: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

✓ My open pastures would get a break when needed: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

✓ A forester helps mark and market the thinning: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

13. How interested are you in planting trees in low numbers on all or part of your pastureland with the intention of letting your livestock eventually graze among them (basically create a silvopasture in all or some of the places you run livestock): **(Please circle only one number)**

Interest level increases from left to right →

I am not interested		I am interested		I am very interested
1	**2**	**3**	**4**	**5**

In a few words, please let us know why you feel this way *(please skip if you don't care to share)*

_____

_____

Would any of the following increase your interest and, if so, how much?

My livestock would benefit from the shade: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

✓ I could get environmental payments for doing so: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

✓ The long-term timber return would be highly profitable: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

✓ NRCS provides technical and cost-share assistance: ☐ Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

✓ The time and protection needed for silvopasture fits within my farm budget: ☐Yes ☐ No

If yes, how much? ☐ A little bit ☐ A fair amount ☐ A lot

14. Please indicate your general interest in silvopasture: **(Please circle only one number)**

Interest level increases from left to right →

I am not interested		I am interested		I am very interested
1	**2**	**3**	**4**	**5**

What concerns you most about silvopasture? What excites you about it? *(skip if nothing comes to mind)*

_____

_____

15. How many acres of the total land where you graze livestock is forested (an estimate is fine)?_____ **Acres**

16. What percentage of the total land where you graze livestock is forested (an estimate is fine)? _____**%**

17. What types of grazing do you use with your livestock? **(check all the apply)**

☐ Rotation between different pastures ☐ Continuous grazing in one pasture ☐ Woodland grazing

☐ Rotation between pasture and forest ☐ Management intensive grazing

☐ Other _____

ONE MORE PAGE TO GO! Thanks for your time and patience.

18. How do you feel about each of the following statements? **(Please circle only one number for each)**

Statement is…	A terrible idea	An okay idea	A great idea
Planting trees in a pasture is…	1	2	3
Thinning a forest to graze livestock in is…	1	2	3
Managing trees, livestock, and forage together is…	1	2	3
Adding tree management into your farm schedule is…	1	2	3

19. If the following statements were true, how much would each ***increase your interest*** in silvopasture? **(Please circle only one number for each statement)**

Statement is…	Not at all	A little	Somewhat	Quite a Bit	A lot
You know of and have seen a successful example	1	2	3	4	5
You receive cost-share assistance	1	2	3	4	5
You do not hinder livestock productivity	1	2	3	4	5
You can implement it without buying equipment	1	2	3	4	5
You can implement it out with no risk	1	2	3	4	5

20. How much do you agree or disagree with the following statements about silvopasture? **(Please circle only one number for each statement)**

Statement is…	Disagree	Maybe	Generally Agree	Strongly Agree
I know how to implement silvopasture	1	2	3	4
NRCS knows how to implement silvopasture	1	2	3	4
I know where to find silvopasture information	1	2	3	4
Putting money into silvopasture seems risky	1	2	3	4
I think my land is well-suited for silvopasture	1	2	3	4
Most producers I know would think it is crazy	1	2	3	4
My friends and family would not think it's all that crazy	1	2	3	4

Below are a few demographic questions – please recall our mandate to protect your confidentiality but we understand if you are not comfortable answering one or more of them

21. What year were you born? _____ 22. Are you? ☐ **Male** or ☐ **Female**

23. Please indicate your race/ethnicity

☐ Hispanic/Latino ☐ Asian/Pacific Islander ☐ Black or African American

☐ White ☐ Native American or American Indian ☐ Other

24. What is the highest level of education you have completed? **(Please check only one box)**

☐ Some high school ☐ High school / GED ☐ Associates degree ☐ Bachelors ☐ Graduate degree

25. What was your approximate 2017 household income before taxes? **(Please check only one box)**

☐ Less than $24,999 ☐ $25,000 to $49,999 ☐ $50,000 to $99,999 ☐$100,000 to $149,999

☐ $150,000 to $200,000 ☐ More than $200,000

Do you have thoughts or reactions that you would like to share? (if so, use the space below)

FINISHED! Thanks for your effort and input.

Appendix C. Institutional Review Board Permission Letter

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: October 29, 2018

TO: John F Munsell, Philadelphia Wilkens

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)

PROTOCOL TITLE: Silvopasture in Virginia

IRB NUMBER: **18-585**

Effective October 29, 2018, the Virginia Tech Institution Review Board (IRB) approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

https://secure.research.vt.edu/external/irb/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 5,7**
Protocol Approval Date:	**September 20, 2018**
Protocol Expiration Date:	**September 19, 2019**
Continuing Review Due Date*:	**September 5, 2019**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.