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Potential adoption of agroforestry riparian buffers based on landowner and streamside characteristics

K.E. Trozzo, J.F. Munsell, J.L. Chamberlain, and W.M. Aust

Abstract: Riparian forest buffers provide numerous environmental benefits, yet obstacles to landowner adoption are many. One barrier is the perception that riparian forest buffers are used for conservation at the expense of production. We present a study that focused on why landowners are more or less inclined to adopt native fruit and nut tree agroforestry riparian buffers that achieve both. We surveyed owners of nonforested streamsides in three Virginia watersheds and grouped survey respondents into three segments: (1) stream-source livestock producers, (2) alternative-source livestock producers, and (3) nonproducers. We also measured the importance owners place on management outcomes, their beliefs about riparian forest buffer effectiveness, and their reaction to potential benefits associated with using native fruit and nut tree agroforestry systems. We then tested whether these variables differ among streamside owner segments. Differences were observed in importance of land use outcomes, riparian buffer beliefs, and responses to potential benefits of native fruit and nut tree systems. A geographic information system was used to study streamside characteristics, which varied across owner segments in total potential planting space but differed more so in the total amount of erodible soil that could be conserved through the use of native fruit and nut tree buffers. Results suggest that conservation programs focused on native agroforestry systems would benefit by prioritizing and tailoring initiatives according to social and biophysical variables.

Key words: conservation buffers—conservation plantings—landowner segmentation—native species—riparian forest buffers—small scale forestry

Riparian forest buffers are naturally occurring or planted forests adjacent to water bodies. They are useful for conserving soil, protecting water quality, stabilizing stream banks, and helping to filter and recharge groundwater (Castelle et al. 1994; Shultz et al. 2009). Riparian forest buffers also collect sediment and debris during flood events and can reduce downstream flooding (Lowrance et al. 1997). They decrease nonpoint source pollution by immobilizing, storing, and transforming nitrogen (N), phosphorus (P), and agricultural chemicals and provide food and habitat for terrestrial and aquatic wildlife (Peterjohn and Correll 1984; Governo and Lockaby 2004; Pinho et al. 2008; Shultz et al. 2009).

Because of these benefits, riparian buffers often are central to water quality protection or restoration initiatives. For example, President Barack Obama signed Executive Order 13508 in 2009, which sets goals to restore and maintain 291,999 km (181,440 mi) of riparian forest buffers in the Chesapeake Bay Watershed by 2025. Reaching this goal means establishing 23,174 km (14,400 mi) of new buffers and projects are underway to achieve this objective via partnerships, technical support, and outreach (Federal Leadership Committee for the Chesapeake Bay 2010).

At the same time, many landowners often think riparian forest buffers are visually displeasing and significantly limit water access (Ryan et al. 2003; Lovell and Sullivan 2006; Ranganath et al. 2009). In addition, buffers can considerably decrease streamside access for livestock production and other crops and their costs can be prohibitive (Featherstone and Goodwin 1993; Castelle et al. 1994). Because of these factors, riparian conservation and production often are treated as mutually exclusive (Robles-Diaz-de-Leon 1998). However, multifunctional agroforestry riparian buffers offer landowners and managers a system that can produce food, fodder, and timber while conserving soil and protecting water (Robles-Diaz-de-Leon 1998; Shultz et al. 2009).

Research has shown that adoption of multifunctional agroforestry systems is related to owner beliefs and land use objectives (Featherstone and Goodwin 1993; Matthews et al. 1993; McGinty et al. 2008; Arbuckle et al. 2009; Kaunekis and York 2009; Valdivia and Poulos 2009). Most owners have several objectives and potentially could be more inclined to adopt multifunctional buffers to produce fruits, nuts, and wood fiber for sale and/or personal use while also conserving water, soil, and habitat (Robles-Diaz-de-Leon 1998; Butler and Leatherberry 2004).

Matthews et al. (1993) found that despite potential increases in effort and cost, landowners that identified strongly with stewardship principles were more likely to be interested in agroforestry. Kaunekis and York (2009) observed that land use was an important factor in adoption of voluntary forest conservation programs. According to Arbuckle et al. (2009), landowners who value recreation and environmental objectives often are more interested in agroforestry than those motivated by financial outcomes. For instance, Featherstone and Goodwin (1993) found that landowners who primarily manage livestock invest less in conservation.

Landowner demographics also relate to adoption of agroforestry practices (Konyar and Osborn 1990; Matthews et al. 1993; Lynch and Brown 2000; McGinty et al. 2008; Arbuckle et al. 2009). Featherstone and Goodwin (1993) and Pattanayak et al. (2003) found that income positively correlates with agroforestry adoption. Landowners with higher levels of education are more likely to use riparian forest buffers (Traore et al. 1998; Cooper and Jacobson 2009). Amenity and

Katie E. Trozzo is a graduate research assistant at Virginia Polytechnic Institute and State University in Blacksburg, Virginia. **John F. Munsell** is an associate professor at Virginia Polytechnic Institute and Virginia State University in Blacksburg, Virginia. **James L. Chamberlain** is a research scientist with the USDA Forest Service in Blacksburg, Virginia. **W. Michael Aust** is a professor at Virginia Polytechnic Institute and State University in Blacksburg, Virginia.

cultural motivations also are important, and in some cases more influential than financial considerations (Matthews et al. 1993; Ryan et al. 2003; Strong and Jacobson 2005; Arbuckle et al. 2009; Barbieri and Valdivia 2010).

Some research focuses on how and why agroforestry adoption varies among segments, or types of landowners. Strong and Jacobson (2005) used segment techniques to study landowner preferences for crops that could be managed using agroforestry practices. One segment focused on timber, another on livestock, and a third on specialty crops. A fourth segment was labeled nonadopters. Livestock-focused owners were most interested in agroforestry economics and production. Specialty crops owners were most interested in producing food and improving wildlife habitat, yet were still interested in production and revenue. All of the landowner segments, including nonadopters, identified environmental benefits as the most important advantage of agroforestry.

Barbieri and Valdivia (2010) identified productivist and ruralist segments based on whether or not they were involved in farming, the amount and type of on-property recreation and interest in agroforestry. Productivists were primarily farmers who were motivated by monetary-based management objectives and participated in recreation tied to land use production, such as hunting. Most ruralists, on the other hand, were not farmers, mainly reported having amenity-based management objectives, and recreated along the lines of hiking and bird watching. In general, productivists were less interested in agroforestry when compared to ruralists. However, they were most interested in agroforestry buffers because of revenue potential in addition to benefits of stream bank stabilization and preservation of productive bottomlands.

Our study occurred in three Virginia watersheds where livestock management is a dominant land use. A geographic information system (GIS) was used to draw a sample of nonforested streamside owners. Sampled owners were sent a questionnaire to measure importance placed on land use outcomes, livestock management, demographics, beliefs about riparian buffer effectiveness, and potential adoption of and reactions to native fruit and nut tree agroforestry buffers.

Multifunctional native fruit and nut trees can be incorporated and managed in Zone 2 of Welsh's (1991) 3-zone agroforestry riparian buffer (figure 1). Native production can include fruits, nuts, honey, maple syrup, floral products, weaving and dying materials, timber, fuel wood, and therapeutic herbs (Shultz et al. 2009). These multifunctional agroforestry buffers enhance ecosystem resiliency by increasing the diversity of native species and products. They also are naturally adapted to regional pests and disease.

Respondents were segmented into streamside owner types according to land use objectives and livestock management. Segments were used to test the hypothesis that demographics, beliefs, outcome importance, potential adoption, and reactions differ among types of streamside owners. Results were compared to previous research and evaluated with respect to conservation impacts and initiatives.

Additionally, GIS and digital databases were used to compile and analyze streamside data that correspond to questionnaire results. We evaluated landowner and streamside variables simultaneously because the potential soil and water conservation benefits associated with the adoption of agroforestry riparian buffers are derived from total area of, and potential erosion in, riparian areas. Combining streamside area and erodibility with owner and land use characteristics could more comprehensively depict prospective conservation and production via multipurpose, agroforestry riparian buffers.

Materials and Methods

Three watersheds in western Virginia were included in the study (figure 2). Each watershed has similar amounts of farm and forest land, and livestock management is a popular land use. The Smith Creek Watershed of the North Fork Shenandoah in the Potomac River Basin is a Natural Resources Conservation Service (NRCS) priority watershed and located in the Chesapeake Bay Watershed. The Catawba Creek Watershed of the Upper James River in the Lower Chesapeake River basin is in the headwaters of the Chesapeake Bay Watershed and home to several conservation-oriented landowner groups. The Lower Reed Creek Watershed of the Upper New River in the Kanawha River Basin was included to cover another major watershed in western Virginia. GIS and digital data for county tax parcels, streams, and forest cover were used to identify qualified parcels. To focus on larger holdings and impactful waterways, properties 2.02 ha (5 ac) and above with stream orders of one to four were randomly selected.

The study population consisted of 1,729 parcels. A random sample of 1,121 parcels was drawn from the population using 95% confidence interval assuming a 0.03 margin of error and removing duplicate owners (after Dillman et al. 2009). Of the sampled properties, 469 (42%) qualified for the study because they included at least one streamside section with less than 10% canopy cover across a contiguous area at least 18.2 m (60 ha) in linear stream length and 22.8 m (1/10th ac) (table 1; figure 3). The dimension constitutes the lowest acreage that can be enrolled in the Conservation Reserve Enhancement Program (CREP). The Conservation Reserve Enhancement Program is an NRCS program where streamsides are rented and vegetated to conserve soil and protect water quality for a period up to 15 years (USDA Farm Service Agency 2012).

Qualified properties were identified using aerial imagery, the National Hydrography Dataset (NHD), and digitized tax parcels. Aerial imagery was used to analyze canopy cover within minimum streamside dimensions and the NHD was used to identify streams. Owners of qualified properties were surveyed using the Tailored Design Method by Dillman et al. (2009). A letter notified the owner that a questionnaire is forthcoming, followed a week later by a questionnaire and cover letter describing the study. A reminder postcard was delivered a week later, and three weeks after that a replacement questionnaire was mailed to complete the sequence. Demographic data and land characteristics among early and late respondents were compared to check for nonresponse bias (after Groves et al. 2002).

The questionnaire was designed to measure current land use, reasons for owning land, importance of land management outcomes, demographics, perceptions of planting native fruit and nut tree riparian forest buffers, and influence of potential benefits on landowner intentions to plant. Biophysical data were compiled for each qualified streamside using tax parcel information, National Hydrography Data (NHD), and NRCS soil survey geographic data (SSURGO). To avoid confusion, the questionnaire listed potential native fruit and nut tree and shrub species and included illustrations of multifunctional native fruit and nut tree riparian forest buffers (figure 4). Because the NHD was derived from

Figure 1
USDA 3-Zone Riparian Forest Buffer Planning Model (as depicted by Virginia Outdoors Foundation [2010]).

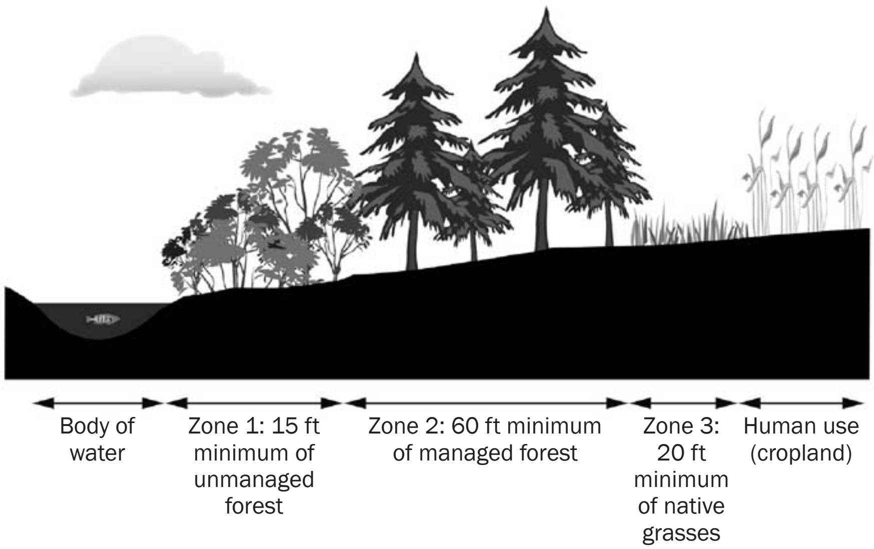
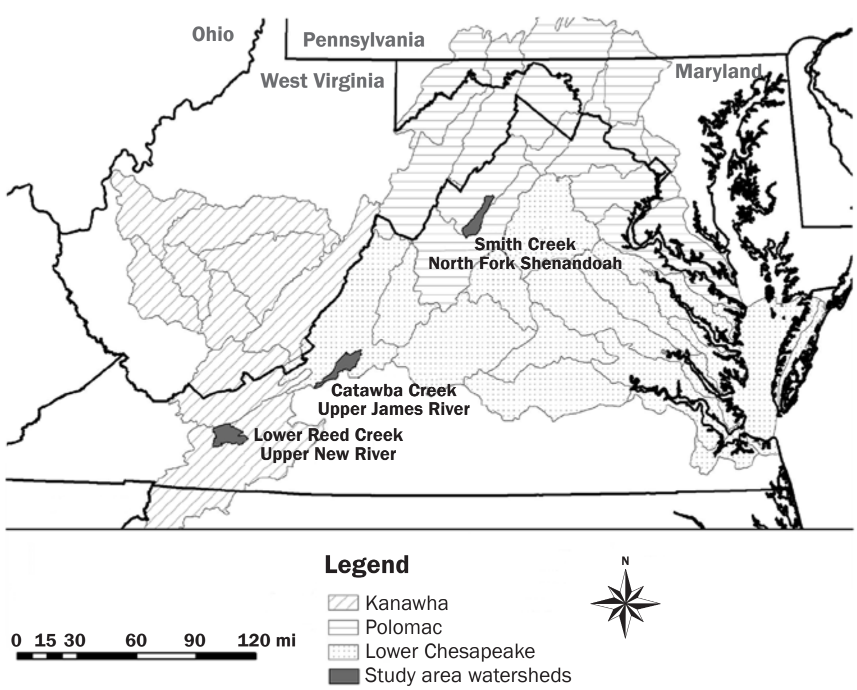


Figure 2
Study area subwatersheds in western Virginia: Smith Creek, Catawba Creek, and Lower Reed Creek. Also denoted are the major basins wherein the watersheds are located.



maps developed in the 1970s, sampled owners were asked to return their questionnaire with "no creek" written in the comments section if they no longer have stream flow at least part of the year.

Owners also were asked to select the top three reasons for owning land from a discrete list divided into monetary-based and amenity-based objectives. The categories conceptually align with Barbieri and Valdivia's (2010) productivist and ruralist segments and distinguish owners using a close-ended selection of the most important objectives. Monetary objectives were farming, land investment, leasing, growing timber, and home investment. Amenity objectives were beauty, hunting, pass land to heirs, wildlife habitat, and nature. If two or more selections were monetary in nature, the respondent was categorized as a monetary owner. If two or more amenity objectives were selected, they were categorized an amenity owner. Owners also were asked whether they graze livestock on their property. Those that graze were asked about their primary watering source.

Age, gender, education, income, work status, and years of property ownership were measured. Owners also were asked if they considered themselves a farmer, lived more than nine months each year on their property, and had previously planted woody vegetation in riparian areas. To identify working properties, owners were asked if they sell more than US$1,000 of products annually (Weber and Ahearn 2012). Biophysical data were compiled and analyzed using GIS. Data included parcel size, stream frontage, potential planting space, and the amount and proportion of highly, potentially, and nonerodible soil in qualified streamside areas. Stream frontage is the amount of linear feet in streams on the property. Potential planting space is the summed area of all qualified nonvegetated streamsides. The amount and percent of highly, potentially, and nonerodible soil were determined using the Soil Survey SSURGO Database.

Importance of land management outcomes was measured using a 4-point unipolar importance scale, where 1 = not at all important and 4 = very important (table 2). A 5-point bipolar agreement scale was used to measure perceived benefits of riparian forest buffers, where 1 = strongly disagree, 3 = neutral, and 5 = strongly agree. The effects of potential benefits on intention to plant

Table 1

Landowner populations with streamsides in each of the three study watersheds in Virginia. The size of the random sample drawn, number of sampled owners with nonforested streamsides that qualified for study, and usable responses.

Subwatershed	Population	Sample	Nonforested streamsides	Usable responses
Smith Creek	507	344	169	52
Catawba Creek	639	400	158	55
Lower Reed Creek	583	377	142	43
Total	1,729	1,121	469	150

Figure 3

Example aerial images of (a) forested and (b) nonforested creek sides used to distinguish properties that were and were not qualified for study of potential adoption of agroforestry riparian forest buffers.

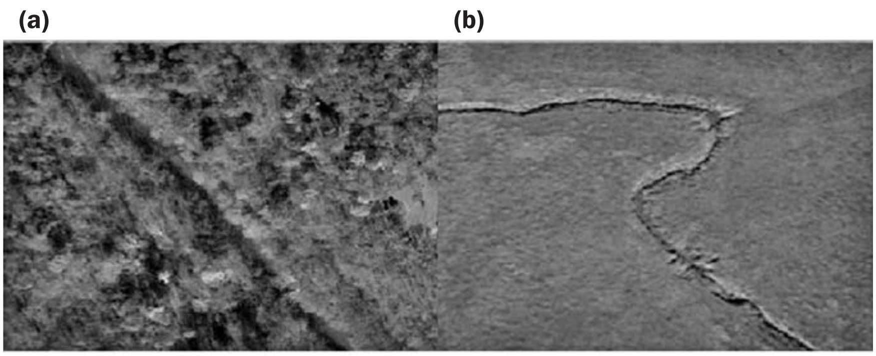
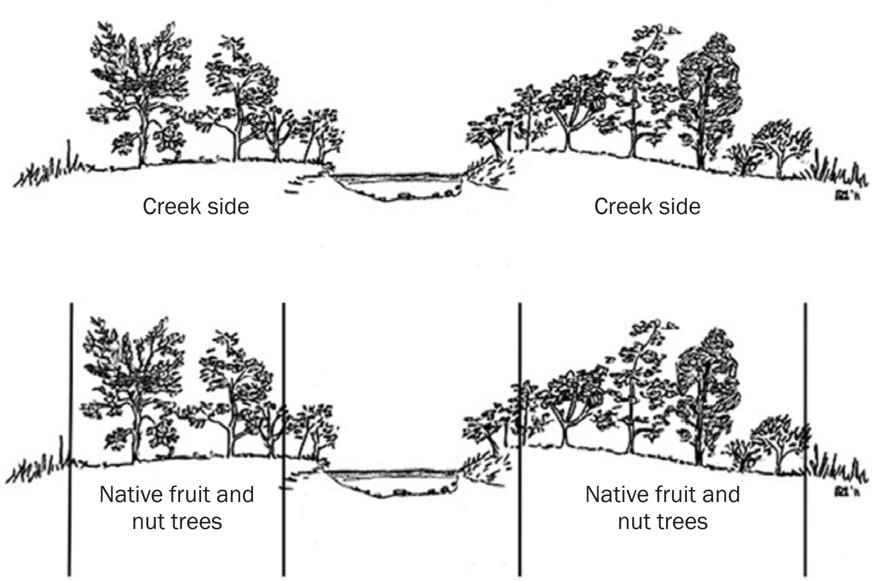


Figure 4

Images of agroforestry riparian forest buffers included in the streamside owner questionnaire. The bottom image distinguishes planting location of native fruit and nut trees. Illustration provided by Elizabeth Anderson Moore.



native fruit and nut trees were measured by presenting beneficial results of planting and asking if intention to plant would increase if the result was true. Effects were measured using a 5-point unipolar scale, where 1 = not at all increase and 5 = increase a lot.

Cluster analysis is used to segment landowners based on one or more variables (e.g., Strong and Jacobson 2005; Butler and Leatherby 2004; Munsell et al. 2008; Barbieri and Valdivia 2010). Two-step cluster analysis was used to segment landowner respondents according to silhouette measures of cohesion and separation. Good silhouette measure of cohesion and separation (above 0.5 out of 1.0) means intrasegments are adequately similar and intersegments adequately different. Categorical and/or continuous variables can be used in a two-step cluster analysis. Reason for owning land, livestock ownership, and primary drinking source for livestock were used to segment owner respondents.

Demographics and land use characteristics were used to describe each segment. An independent samples nonparametric median procedure in PASW Statistics 20, Release Version 20.0.0, was used to test for significant differences in median responses between streamside owner segments (α = 0.10). The procedure is useful when analyzing ordinal data because it does not assume a population parameter. It splits all sample data into two groups according to whether data points are above or at or below the overall median and then uses Pearson χ^2 to test the hypothesis that medians for two or more groups of independent samples are the same. Medians were used to avoid bias associated with nonnormal, skewed responses and because data were ordinal. Findings are combined with area of qualified streamsides and erodible soil to interpret implications for conservation.

Four hundred and sixty questionnaires were successfully delivered and 277 were returned for an adjusted response rate of 60%. Fifty-five (19.8%) parcels did not have stream flow at least part of the year. Of the remaining 222 questionnaires, 150 surveys (or 32.6% of successfully delivered total) contained complete data (table 1). Study parcels contained 101.3 km (63 mi) of streams and 218 ha (539 ac) of potential riparian planting area. No differences were observed between late and early respondents. Owner segments exhibited good silhouette measure of cohesion and separation (0.6 out of 1.0).

Table 2
Indicators and Likert-type scale used to measure importance placed on land use outcomes, perceived benefits of riparian forest buffers, and hypothetical outcomes that affect intention to plant native fruit and nut tree riparian buffers.

Measure	Indicators*
Land use outcomes	Keeping land manicured
	Making money
	Producing goods
	Keeping a natural state
	Improving wildlife habitat
Perceived benefits	Riparian buffers are unsightly
	Riparian buffers make streamsides inaccessible
	Riparian buffers improve water quality
	Riparian buffers decrease production
	Riparian buffers considerably reduce erosion
If the following outcomes were true, how much would each increase your intention to plant native fruit and nut trees on your creek sides in the next three years?	You get 75% of the planting paid for by the government
	You make money selling fruits and nuts
	You supply your friends and family with fruits and nuts
	You improve the local economy near your land
	You improve water quality in the region
	You improve wildlife habitat on your land
	You enhance scenery on your land
	You decrease soil loss on your creek side

*Means of Likert scales. Likert scales for the land use outcomes are 1 = not important at all to 4 = very important. Likert scales for the perceived benefits are 1 = strongly disagree to 5 = strongly agree. Likert scales for intention increases are 1 = not increase at all to 5 = increase a lot.

The first segment is referred to as the stream-source livestock producers, and includes 62 streamside owners (41%) that have livestock and use their stream as a primary water source for them (table 3). Most are monetary owners, or those with land management objectives primarily focused on financial returns. The second segment is referred to as the alternative-source livestock producers, and includes 37 owners (25%) that water livestock using sources other than their streams and are mostly monetary owners. The third segment is referred to as nonproducers, and consists of 51 streamside owners (34%) that may extensively or intensively manage their property but do not produce livestock. Roughly two out of every three nonproducers were classified as amenity owners, or those with land management objectives primarily focused on nonmonetary returns. Only a small percentage (14%) makes more than US$1,000 from their land annually. The majority of respondents across all segments were male, about 40% were retired, and most live more than nine months per year on their property (table 4). Property ownership length was generally the same.

Sixty percent of stream-source livestock producers were between 50 and 69 years of age (table 4). Forty-four percent had bachelors or graduate degrees. Forty-five percent made between US$50,000 and US$100,000 annually and 16% made more than US$100,000. Farmers accounted for 23% of this segment and two thirds (66%) made more than US$1,000 from their property per year. Only 10% had planted streamsides.

Forty-six percent of alternative-source livestock producers were between the ages of 50 and 69 and 38% were 70 or more (table 4). Thirty-eight percent had bachelors or graduate degrees. Twenty-nine percent made greater than US$100,000 and 34% made between US$50,000 and US$100,000. Sixteen percent reported being farmers and over half noted that they made more than US$1,000 from their property in a year. Sixteen percent of this segment had planted streamsides.

Sixty-six percent of nonproducers were between 50 and 69 years of age (table 4). Fifty-seven percent had bachelors or graduate degrees and 30% made more than US$100,000. Only 8% of this segment considered themselves farmers, just 7 of the 51 made more than US$1,000 annually from their property. Somewhat differently, 26% had planted streamsides.

Stream-source livestock producers owned an average of 32 ha (78 ac) and 0.5 miles of linear stream (table 5). The average potential planting space was 1.6 ha (4.2 ac) and totaled 106 ha (261 ac). Within the potential planting space, there was an average of 0.8 ha (2 ac) and a total of 51 ha (125 ac) (48%) of highly and potentially erodible soil. There was an average 0.9 ha (2.2 ac) and total of 55 ha (136 ac) (52%) of nonerodible soil.

Alternative-source livestock producers owned an average of 24.6 ha (61 ac), 0.3 miles of linear stream, and 1.5 ha (3.7 ac) of plantable space (table 5). They owned a total of 56 ha (138 ac) of potential planting area within streamsides. Highly and potentially erodible soil accounted for an average of 1.2 ha (3 ac) within the potential planting space and totaled 45 ha (112 ac) (81%). Nonerodible soil averaged 0.3 ha (0.7 ac) (19%) or 11 ha (26 ac) total.

Nonproducers owned an average of 15 ha (38 ac) and 0.3 miles of linear stream (table 5). They possessed an average of 0.93 ha (2.3 ac) and 47 ha (117 ac) total of potential planting space that consisted of an average of 0.4 ha (1.1 ac) and total of 22.6 ha (56 ac) (48%) of highly and potentially erodible soil. They owned an average of 0.48 ha (1.2 ac) and 25 ha 61 ac) total (52%) of nonerodible soil.

Median importance of improving wildlife habitat, making money, and producing goods differed significantly between owner segments (table 6). Medians for improving wildlife habitat were higher for all segments when compared to making money and producing goods. Maintaining a natural state, improving the environment, and keeping manicured property did not significantly differ. Post hoc pairwise comparisons indicated several differences between nonproducers and stream-source livestock producers (table 7). Medians for alternative-source livestock producers and stream-source livestock producers were the same, but alternative-source livestock producers did not differ significantly from nonproducers.

Median perceptions regarding erosion reduction differed significantly between owner segments, whereas decreases in streamside access, production, water quality improvement, and wildlife enhancement did not (table 6). Post hoc pairwise comparisons showed that nonproducers were more likely than alternative-source livestock producers to strongly agree that riparian forest buffers significantly reduce erosion (table 7). Stream-source livestock producers and alternative-source livestock producers had the

Table 3
Percent and number of cases for each owner variable within segments created using two-step cluster method.

Landowner variables	Category	Landowner segments (*n* = 150) Stream-source livestock producers (%) (*n* = 62)	Alternative-source livestock producers (%) (*n* = 37)	Nonproducers (%) (*n* = 51)
Livestock grazed	Yes	100 (*n* = 62)	95 (*n* = 35)	0 (*n* = 0)
Livestock water from creek	Yes	100 (*n* = 62)	0 (*n* = 0)	0 (*n* = 0)
Reasons of owning land	Monetary	71 (*n* = 44)	73 (*n* = 27)	37 (*n* = 19)
	Amenity	29 (*n* = 18)	27 (*n* = 10)	63 (*n* = 32)

Table 4
Demographics and characteristics of landowner respondents within each owner segment by percentage.

Variables	Categories	Owner segments Stream-source livestock producers (%) (*n* = 62)	Alternative-source livestock producers (%) (*n* = 37)	Nonproducers (%) (*n* = 51)
Watershed	Smith Creek	34	35	35
	Catawba Creek	37	30	41
	Lower Reed Creek	29	35	24
Age (y)	≤ 49	16	16	12
	50 to 69	60	46	65
	≥ 70	24	38	22
Gender	Male	66	76	65
	Female	34	24	35
Education	High school	26	38	29
	Associate/some college	30	24	14
	Bachelors/graduate	44	38	57
Income (US$)	≤ 24,999	17	13	12
	25,000 to 49,999	23	25	20
	50,000 to 99,999	45	34	39
	100,000 to 149,999	8	16	15
	≥ 150,000	8	13	15
Retired	Yes	38	43	43
	No	62	57	57
Live >9 months on property	Yes	71	76	69
	No	29	24	31
Years owned (y)	Mean	22	25	19
Farmer	Yes	23	16	8
	No	77	84	92
Make >US$1000 from the property y^{-1}	Yes	66	50	14
	No	34	50	86
Planted creek side before	Yes	10	16	26
	No	90	84	74

same median, but again the latter did not differ significantly from nonproducers.

Increases in median intention to plant native fruit and nut trees differed between segments in terms of improving wildlife habitat and water quality, and providing friends and family with native fruits and nuts (table 6). On the other hand, enhancing scenery and the local economy, decreasing erosion, having 75% of the cost paid, and making money by selling native fruits and nuts did not differ. Post hoc test results showed that for wildlife habitat and water quality, stream-source livestock producers and alternative-source livestock producers shared similar medians yet alternative-source livestock producers did not differ from nonproducers (table 7). Alternative-source livestock producers and nonproducers medians were higher when compared to stream-source livestock producers in terms of providing friends and

Table 5
Mean, minimum, and maximum parcel size, stream frontage, and amounts of highly, potentially, and nonerodible soil possessed by owners in each segment.

	Stream-source livestock producers (*n* = 62)				Alternative-source livestock producers (*n* = 37)				Nonproducers (*n* = 51)			
Variable	Mean	se	Minimum	Maximum	Mean	se	Minimum	Maximum	Mean	se	Minimum	Maximum
Parcel size (ac)	78	11	50	320	61	11	50	253	38	7	5.	246
Stream frontage (mi)	0.5	0.1	04	2.1	0.3	0.1	03	1.3	0.3	0.1	0.04	2.1
Plantable area (ac)	4.2	0.5	0.41	19.1	3.7	0.6	0.40	13.4	2.3	0.3	0.20	12.4
Highly erodible soil (ac)	1.5	0.3	00	14.1	1.7	0.4	00	9.8	0.7	0.2	0	5.8
Potentially erodible soil (ac)	0.5	0.1	00	2.6	1.3	0.1	00	4.1	0.4	0.1	0	1.4
Nonerodible soil (ac)	2.2	0.3	00	8.7	0.7	0.2	00	4.1	1.2	0.3	0	10.2

Table 6
Results of nonparametric median test to for differences in importance of land use outcomes, perceived impacts, and expected outcomes differ between three owner segments (α = 0.10).

Category	Variable	Significance
Land use outcomes	Producing goods	0.00*
	Making money	0.03*
	Improving wildlife habitat	0.01*
	Keeping a natural state	0.44
	Keeping land manicured	0.32
Perceived impacts	Riparian buffers considerably reduce erosion	0.01*
	Riparian buffers make streamsides inaccessible	0.09*
	Riparian buffers improve water quality	0.49
	Riparian buffers decrease production	0.81
	Riparian buffers are unsightly	0.19
If the following outcomes were true, how much would each increase your intention to plant native fruit and nut trees on your creek sides in the next three years?	You improve wildlife habitat on your land	0.02*
	You improve water quality in the region	0.07*
	You supply your friends and family with fruits and nuts	0.05*
	You improve the local economy near your land	0.59
	You make money selling fruits and nuts	0.85
	You get 75% of the planting paid for by the government	0.13
	You enhance scenery on your land	0.10
	You decrease soil loss on your creek side	0.13

* indicates significant difference between owner segments

family with native fruits and nuts, but only nonproducers and stream-source livestock producers differed significantly.

Results and Discussion

Demographics and owner characteristics generally did not differ between segments. One exception was that half as many stream-source livestock producers made over US$100,000 per year when compared to other segments. Another was that a much higher percentage of stream-source and alternative-source livestock producers considered themselves farmers and reported making more than US$1,000 per year from their land. Interestingly, the percent of nonproducers that have planted before was more than twice as high when compared to stream-source and alternative-source livestock producers. Earlier findings from research on the relationship between livestock management and riparian plantings demonstrate the same (Featherstone and Goodwin 1993). With respect to potential planting, owner segments differed according to streamside characteristics, importance of land use outcomes, beliefs about riparian plantings, and response to potential results from using native fruit and nut tree agroforestry systems.

Average parcel size for stream-source and alternative-source livestock producers was roughly the same. Nonproducers owned about half as much on average. However, the total area of qualified streamsides owned by stream-source livestock producers was about twice that for alternative-source livestock producers and nonproducers. Highly and potentially erodible soil accounted for just under half of the potential planting area owned by stream-source livestock producers and nonproducers. Thus the difference in total potential planting acreage between the two segments mirrored their differences in the total area that is highly or potentially

Table 7
Results of post hoc comparisons of significantly different median responses related to importance of land use outcomes, perceived impacts, and expected outcomes between three owner respondent segments.

Variable	Post hoc segment comparison	Median	*t*-statistic	Adjusted significance
Producing goods (land use outcome)	Stream-source livestock producer/alternative-source livestock producer	3 3	0.18	1.00
	Stream-source livestock producer/nonproducer	3 2	16.20	0.00*
	Alternative-source livestock producer/nonproducer	3 2	10.91	0.00*
Making money (land use outcome)	Stream-source livestock producer/alternative-source livestock producer	2 2	0.05	1.00
	Stream-source livestock producer/nonproducer	2 1	6.21	0.04*
	Alternative-source livestock producer/nonproducer	2 1	4.06	0.13
Importance of wildlife habitat (land use outcome)	Stream-source livestock producer/alternative-source livestock producer	3 3	3.86	0.15
	Stream-source livestock producer/nonproducer	3 3	8.65	0.01*
	Alternative-source livestock producer/nonproducer	3 3	0.52	1.00
Supply food to family and friends (intention increase)	Stream-source livestock producer/alternative-source livestock producer	1 2	0.02	1.00
	Stream-source livestock producer/nonproducer	1 2	5.00	0.08*
	Alternative-source livestock producer/nonproducer	2 2	3.12	0.23
Water quality improvement (intention increase)	Stream-source livestock producer/alternative-source livestock producer	3 3	0.22	1.00
	Stream-source livestock producer/nonproducer	3 4	5.05	0.07*
	Alternative-source livestock producer/nonproducer	3 4	2.26	0.40
Improving wildlife habitat (intention increase)	Stream-source livestock producer/alternative-source livestock producer	3 3	1.73	0.57
	Stream-source livestock producer/nonproducer	3 2	8.72	0.01*
	Alternative-source livestock producer/nonproducer	3 2	0.24	1.00
Considerably reduce erosion (perceived impact)	Stream-source livestock producer/alternative-source livestock producer	4 4	1.28	0.77
	Stream-source livestock producer/nonproducer	4 5	4.45	0.11
	Alternative-source livestock producer/nonproducer	4 5	8.21	0.01*

*indicates significantly different results (α = 0.10) erodible. Alternative-source livestock producers had a much higher percentage of erodible soil. Despite owning only about half of the acreage possessed by stream-source livestock producers, they shared similar amounts of erodible soil.

Stream-source livestock producers placed greater importance on production and revenue outcomes when compared to nonproducers. Arbuckle et al. (2009) reported similar findings regarding preferences for revenue. Additionally, the nonproducer median for making money was the lowest possible response option. Production and revenue results for alternative-source livestock producers did not differ when compared to either segment, but more closely resembled stream-source livestock producers.

When it comes to importance of wildlife habitat, alternative-source livestock producers resembled stream-source livestock producers but did not differ significantly from this or the nonproducer segment. Habitat was clearly a priority for nonproducers, with the median being the highest possible response option. Though wildlife habitat was important to stream-source livestock producers, they were less inclined than nonproducers to emphasize it and more inclined to underscore production and revenue which is similar to findings in Strong and Jacobson (2005) and Barbieri and Valdivia (2010). Alternative-source livestock producers and stream-source livestock producers were similar on all fronts, but not to the extent that they differed significantly from nonproducers.

Most often, beliefs about the capacity of riparian forest buffers to reduce erosion were positive and similar among stream-source and alternative-source livestock producers. Nonproducers were likely to believe more strongly in the ability of riparian forest buffers to conserve soil. In this case though, it was the alternative-source livestock producers and nonproducers that differed significantly. Similar to Strong and Jacobson's (2005) findings that most landowners believe agroforestry is environmentally beneficial, owners in all segments frequently believed or strongly believed that riparian forest buffers substantially reduce erosion, but the median among nonproducers was the highest possible option. The result supports the general point that nonproducers are more inclined toward ruralist perspectives as outlined by Barbieri and Valdivia (2010) and thus potentially more likely to adopt multifunctional agroforestry systems. It also may stem from the fact that alternative-source livestock producers possess a large majority of erodible soil, which could additionally explain why they have opted for alternative water sources.

Nonproducers were more likely than stream-source livestock producers to be influenced by potential benefits related to the use of native fruit and nut tree riparian buffers. Nonproducers were more likely to note increases in their intention to plant if wildlife habitat and water quality were improved and they could provide food to family and friends. Alternative-source livestock producers resembled stream-source livestock producers for all medians, but did not differ significantly from nonproducers. Habitat and water quality improvement had a greater effect on all segments when compared to supplying food to family and friends. Nonproducers and alternative-source livestock producers were similar when it comes to the opportunity to provide food. With respect to emphasis on objectives and capabilities of agroforestry riparian forest buffers, results suggest that alternative-source livestock producers and stream-source livestock producers differed beyond livestock watering strategy. Alternative-source livestock producers were less likely to believe riparian forest buffers are adequate at reducing erosion, which could relate to the substantial amount of erodible soil they own.

From a conservation standpoint, stream-source and alternative-source livestock producer behavior is likely to have a disproportionate effect given they own over two-thirds of potential planting area within streamsides and manage livestock in and around these areas. While the absolute potential for conservation impacts among alternative-source livestock producers may not be as great as stream-source livestock producers, their participation contributes to contiguous coverage. They possess the largest percentage of highly and potentially erodible soil, which brings their erodible streamside acreage into parity with the total owned by stream-source livestock producers. Nonproducers own the smallest amount of total plantable acreage, but when compared to stream-source livestock producers have similar percentages of highly and potentially erodible soil, generally higher income, and twice as much experience planting. When measured against livestock producers in general, nonproducers more strongly emphasize environmental outcomes, believe in the potential for conservation through streamside plantings, and respond to the potential conservation and edible benefits of native fruit and nut tree buffers.

Nonproducers are very interested in wildlife habitat and strongly believe riparian forest buffers reduce streamside erosion. Though their streamsides generally are protected from the effects of livestock, nonproducers own a noteworthy amount of acreage, one-third of which is highly erodible, and some are active and profitable land managers. In general, demographics and ownership characteristics suggest they represent a growing contemporary landowner class. They may be more inclined to adopt multifunctional riparian forest buffers such as native fruit and nut tree systems to achieve outcomes like habitat enhancement and general conservation, in addition to other land uses which may or may not focus on production. Adoption of multifunctional riparian agroforestry systems by these owners may happen more rapidly and provide a starting point for reaching other owners.

Stream-source livestock producers and alternative-source livestock producers were less inclined to think multifunctional agroforestry riparian forest buffers fit into their objectives. A smaller percent have planted riparian areas before when compared to nonproducers, but some see agroforestry systems such as native fruit and nut tree buffers as a compatible production possibility in riparian areas. Though less enthusiastic when compared to nonproducers, results of this study and Strong and Jacobson (2005) suggest the importance of conservation to stream-source and alternative-source livestock producers may be leveraged if production and revenue are possible. Alternative-source livestock producers may be more interested given that they are similar to nonproducers.

This study demonstrates that simultaneous evaluation of biophysical and social variables is useful for marketing multifunctional, native agroforestry systems in support of conservation. The environmental benefits of agroforestry riparian buffers such as water quality, soil conservation, and wildlife habitat are well-known, but reasons for adopting these systems can vary. Owner segments in this research responded differently to potential outcomes of buffer use, which points to the importance of modifying system design according to preferred objectives.

Featherstone and Goodwin (1993) found that livestock producers invest less in conservation and Barbieri and Valdivia (2010) demonstrated that production-focused owners (i.e., productivists) are less interested agroforestry practices. However, Ryan et al. (2003) found that income-earning farmers are likely to adopt production-oriented conservation practices. Economics are a major factor in the adoption of agroforestry systems among many producers (e.g., Matthews et al. 1993). Demonstrating the potential for short-term production and revenue using multifunctional buffers could pay dividends.

The use of native fruit and nut tree buffer systems also could increase among stream-source and alternative-source livestock producers if links to production and conservation benefits are clear. Strong and Jacobson (2005) reported that landowners consider environmental benefits to be an important reason for using agroforestry riparian buffers. Workman et al. (2003) found that landowners in the southeastern United States desire more agroforestry demonstrations. Showcasing possibilities to improve water quality through the use of multifunctional buffer systems could appeal to producers and nonproducers alike. Demonstrating wildlife-friendly and native food-producing systems additionally could increase interest.

Summary and Conclusions

Riparian planting goals, such as those laid out in President Obama's Chesapeake Bay Watershed Executive Order, are increasingly common. The need to develop compatible and refined technical assistance and outreach strategies is growing. Our study focused on prospective adoption of multifunctional agroforestry buffers using a sample of streamside owners in three Virginia watersheds. We studied both owner and streamside data and discussed the implications relative to potential benefits of and barriers to adoption of native fruit and nut tree riparian forest buffers. Mail survey and GIS assessment allowed for useful remote analysis and data coupling. Future research would benefit from contemporary stream data, which could have prevented sampling of owners without present-day stream flow. A potential focus for future research could be to refine strategies for engaging diverse streamside owners to meet property- and watershed-level production and conservation.

Owner segments in this study differed according to the emphasis they place on different management outcomes, the extent to which they believed riparian forest buffers are effective, and the influence of different results on their intention to plant native fruit and nut trees. While differences were along production and wildlife habitat lines, the relative emphasis on environmental services points to a general proclivity for native systems where production and conservation possibilities are understood. A need for conservation may be highest among those that seem least likely to use them, but multifunctional agroforestry riparian buffers could yet garner a variety of landowner advocates that prompt increases in adoption.

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