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Effects of the sustainable forestry initiative fiber sourcing standard on the average implementation rate of forestry best management practices in Georgia, United States

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A R T I C L E I N F O

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A B S T R A C T

Much of the discourse on the sustainability of forestry resources revolves around certified forestland. It is typically assumed that certified forestland is the hallmark of sustainable forestry. This reasoning has led to a general perception that uncertified forestlands are not sustainably managed. In this regard, the role of the Sustainable Forestry Initiative (SFI) Fiber Sourcing Standard is instrumental in promoting sustainable forest management on uncertified forestlands. We used an advanced spatial approach to determine the influence of the SFI Fiber Sourcing Standard over space and time on Georgia's forestlands. We also assessed differences in the implementation rate of forestry Best Management Practices (BMPs) in Georgia on harvested sites located within the sourcing radius of mills certified to SFI Fiber Sourcing Standard relative to those harvest sites located outside the sourcing radius of certified mills. Our results suggest that the SFI Fiber Sourcing Standard affects 80% or more of total forestland in Georgia. We also found that the average BMP implementation rate on harvested sites located within the sourcing radius (about 65 km) of certified mills is about 2% higher relative to harvested sites located outside the sourcing radius of such mills over time. Our results indicate that the SFI Fiber Sourcing Standard is helping in ensuring sustainability of forestlands in Georgia, as forestry BMPs are an important indicator of sustainable forest management. We hope our results will bring clarity to the overall sustainability of uncertified forestlands in Georgia and other forested regions in North America in the context of global private forest governance systems like the SFI Fiber Sourcing Standard.

1. Introduction

Forest certification systems like the Programme for the Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council (FSC) promote sustainable forestry practices worldwide. Most existing certification systems focus on certification of forest management (this includes forestland certification) and chain of custody (CoC). PEFC certifies over 303 million hectares and 11,000 CoCs worldwide, with over 47 million hectares and 200 CoCs in the United States alone, by endorsing over 30 certification systems (PEFC, 2016).

The Sustainable Forestry Initiative (SFI) is a PEFC endorsed system operating in the United States and Canada which, in addition to forest management and CoC standards, offers a unique Fiber Sourcing Standard for those wood consuming mills that procure wood directly from certified and uncertified forestlands (SFI, 2015). The SFI, 2015–2019 Fiber Sourcing Standard promotes responsible forestry practices through 14 principles, 13 objectives, 21 performance measures, and 55 indicators. These fiber sourcing requirements include measures to broaden the practice of biodiversity, use forestry Best Management Practices (BMPs) to protect water quality, provide outreach to landowners, and use the services of qualified logging professionals who have successfully completed an approved wood producer training program such as Georgia's Master Timber Harvester Program (SFI, 2015). Additionally, the participating wood consuming mills under the SFI Fiber Sourcing Standard must be third-party audited to ensure compliance with the requirements of the standard.

Sustainable wood procurement from uncertified forestlands is especially important in the southeastern United States, a region dominated by family forest landowners for whom forest management certification may be out of reach due to cost considerations. This is especially true in Georgia, the largest roundwood producing state in the United States, where about a half million family forest landowners own about 5.7 million hectares of forestlands, i.e., 58.3% of total forestlands (Oswalt et al., 2014), yet only about 18% of the forestland in Georgia is

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certified to various forest management certification systems including the SFI Forest Management Standards. However, there are nearly 200 primary wood-consuming mills in Georgia out of which 41 consume > 317,514 metric tons (350,000 short tons) of roundwood per year (GFC, 2017) totaling about 65% of total annual roundwood consumed in Georgia. Of the 41 large, wood-consuming mills, 28 were certified to the SFI Fiber Sourcing Standard prior to 2015. As a result, it is generally believed that the SFI Fiber Sourcing Standard is instrumental in ensuring the sustainability of forestry resources in Georgia beyond certified forestlands. In turn, the SFI Fiber Sourcing Standard helps wood consuming mills in Georgia to access national and global markets where buyers are seeking finished wood products made from wood sourced from sustainably managed forestlands.

1.1. SFI fiber sourcing standard and forestry BMPs

A prominent feature of the SFI Fiber Sourcing Standard is adherence to forestry BMPs for maintaining water quality. Wood consuming mills must include a contractual obligation to follow forestry BMPs in their procurement agreements with trained loggers and must perform periodic random checks on harvested sites located on uncertified forestlands that are subject to their own procurement activities. In addition to the BMP audits performed by wood consuming mills certified to the SFI Fiber Sourcing Standard, the Georgia Forestry Commission (GFC) performs a biennial survey throughout the state to track BMP implementation rates on recently (typically less than two years) harvested sites (GFC, 2015). The GFC uses the results of these surveys to comply with the Federal Clean Water Act of 1972 as amended. These surveys follow guidelines in Georgia's Best Management Practices for Forestry manual for estimating the average BMP implementation rate.

Increasing BMP implementation rates concur with the introduction and expansion of the SFI Fiber Sourcing Standard beginning the mid-1990s (Fig. 1). The mean implementation rate of forestry BMPs for the first Georgia survey performed in 1991 was only 65%, but the rate steadily increased and had remained above 90% since 2004 (GFC, 2015). Many forestry experts acknowledge a positive relationship exists between the implementation rate of forestry BMPs and the adoption of the SFI Fiber Sourcing Standard by wood-consuming mills in Georgia over time. However, previous academic research has not attempted to assess the relationship between the SFI Fiber Sourcing Standard and implementation rates of forestry BMPs in Georgia. It is important to explore this relationship as forestry BMPs are a strong indicator of sustainable forest management especially when the maintenance of soil and water resources is a criterion featured in the National Report on Sustainable Forests in the United States (Robertson et al., 2011).

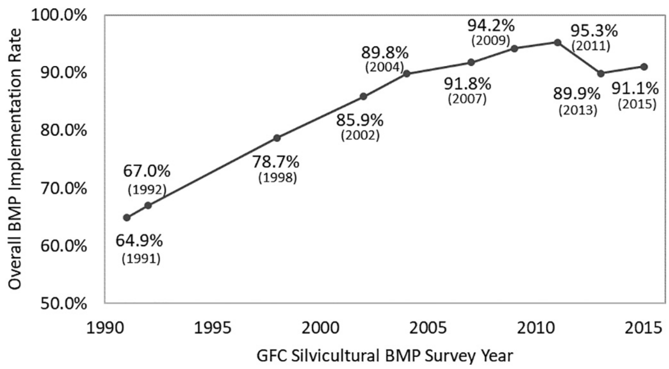

Fig. 1. Overall implementation rates from the Georgia Forestry Commission's Silvicultural Best Management Practices Implementation and Compliance Survey. A decrease in the implementation rate in 2013 is attributed to a historic drought in 2011 and 2012.

2. Literature review

The role of private environmental governance as a tool for ensuring sustainability of forestry resources is critical in modern times. Cashore (2002) developed an analytical framework to understand the emergence of non-state market-driven governance systems and the conditions under which they gain authority for making either new or revising existing policies in the context of forest certification. Gulbrandsen (2004) argued that global private forest governance could be improved by including a broad range of stakeholder groups in standard development, promoting strong environmental and social performance standards in forestry, providing effective control mechanisms, securing producer participation, and through market capture. Ebeling and Yasué (2009) reported that certification is likely to be more successful where governments enforce forestry laws, provide financial incentives for certified forestry, provide land tenure security, and where large-scale and vertically integrated forestry operations are commercially feasible. Sundstrom and Henry (2017) analyzed forest certification data from Brazil and Russia and found that FSC has influenced domestic rhetoric, laws, and enforcement practices over time, showing the influence of private forest governance in shaping national forest policies in selected countries.

Several studies have also investigated the institutional aspects of global private forest governance. Pattberrg (2005) argued that rule-making in the context of FSC towards global governance performs three tasks: a) facilitates a solution to complex multi-interest problems; b) brokers knowledge and norms among diverse stakeholder groups; and c) constitutes a learning network in environmental governance. Bartley (2011) argued that an understanding of the operation of transnational private regulation requires attention to the layering of multiple rules and the politics surrounding them in the context of given geography, as rules related to private governance of forestry resources are not additive in nature, but they create new synergetic networks with the existing rules across scales. Johansson (2012) deliberated that institutional actors have realigned their positions on forest certification in Sweden over time in search for public reputational accountability and market accountability to the extent that management of conflicting views has become a necessity for institutionalizing the concept of private forest governance. Overdevest and Rickenbach (2006) emphasized on the need for matching expectations and satisfaction with forest certification across stakeholder groups for ensuring stronger institutions for effective private forest governance in the United States.

Only a handful of studies have empirically analyzed the impact of forest certification on environmental resources. Marx and Cuypers (2010) reported that the role of certification in preventing deforestation at the global level is limited. Similarly, Johansson and Lidestav (2011) reported only minor improvements in forest conditions in relation to the targets of biological diversity in certified forestlands in Sweden. These improvements were less evident on large-scale properties certified to FSC than small-scale private properties certified to PEFC systems. Kalonga et al. (2016) reported that biodiversity indicators were higher on certified than uncertified forestlands in Tanzania.

A perusal of current literature on global private forest governance regimes suggests that most of the studies have only focused on the FSC Forest Management Standard. There is no study, to the best of our understanding, which focuses on the influence and impact of SFI Fiber Sourcing on forestry BMPs in the United States and Canada. The majority of studies focusing on forestry BMPs in the United States analyze the impact of BMPs on water quality (Aust and Blinn, 2004; Cristan et al., 2016; Grace, 2005). Only a handful of studies have analyzed the economic and welfare impacts of forestry BMPs (Cubbage, 2004; Shaffer et al., 1998; Sun, 2006). Studies which focus on social dimensions of forestry BMPs examine the attitudes of forest landowners and the impact of policy instruments on the adoption of sustainable forest management practices, including BMPs by landowners (Knoot and Rickenbach, 2011; Maker et al., 2014; Mcgill et al., 2006; Munsell et al., 2006; Provencher et al., 2007; Vanbrakle et al., 2013) or other stakeholder groups (Husak et al., 2004; Overdevest and Rickenbach, 2006; Tumpach et al., 2018). Only Newsom et al. (2005) looked at the relationship between forest certification and BMPs in the United States suggesting that in the process of becoming certified, forest landowners are often required to make important changes to their BMP-related practices, especially in those states where forestry BMPs are non-regulatory (e.g., Georgia).

It is critical to explore the relationship between the SFI Fiber Sourcing Standard and BMP implementation rates to evaluate the efficacy of private forest governance towards sustainable forest management. This becomes even more important as anecdotal evidence about the direct connection between BMP implementation and the SFI Fiber Sourcing Standard is a part of parlance within Georgia's forestry stakeholder groups. Therefore, we identified the following three research objectives for this study. First, analyzing the percentage of total land and forestland potentially influenced by the SFI Fiber Sourcing Standard. Second, examining any differences in BMP implementation rates across survey sites located inside and outside of the proposed sourcing radius of wood-consuming mills certified to the SFI Fiber Sourcing Standard. Finally, assessing the potential effect of the SFI Fiber Sourcing Standard on the average BMP implementation rates in Georgia over time. We hope that our research will provide additional insight into the role of the SFI Fiber Sourcing Standard in ensuring an integrated landscape-based sustainable forest management approach.

3. Methods

We compiled a directory of roundwood consuming mills in Georgia using the 2015 Georgia Wood-Using Industries Directory published by the Georgia Forestry Commission (GFC, 2017) and the Primary Forest Products Locator database maintained by the Southern Group of State Foresters (Southern Group of State Foresters, 2017). Locations from these two sources were cross-referenced, and geographical coordinates and roundwood consumption were confirmed. A survey was sent to current mills certified to the SFI Fiber Sourcing Standard (as of 2017) to obtain an initial year of certification with a 59% response rate ($n = 32$). For the mills that did not respond, we obtained the certification year from SFI's records and audit reports.

We used the data from Georgia's Silvicultural Best Management Practices Implementation and Compliance Surveys conducted by the GFC for the years 1998, 2002, 2004, 2007, 2009, 2011, 2013, and 2015. Site-level results were not available for the survey years 1991 and 1992. The number of harvest sites sampled for the GFC's BMP Implementation and Compliance Survey has decreased over time, but sample sizes remained large enough to achieve at least a 5% margin of error (GFC, 2015). To obtain consistent and comparable measurements from year to year, we cross-referenced the questions from each survey year resulting in 103 BMP implementation questions that had been assessed on each survey site for every survey year. The 1998 survey questions were significantly different from 2002 through 2015, so we did not include the 1998 survey in our analysis. To obtain an overall BMP implementation rate for each survey site, we calculated the proportion of compliant answers out of the total number of factors assessed. Questions marked as “Not Applicable” to a survey site were not included in the implementation rate calculation.

We imported the locations of every wood consuming mill certified to the SFI Fiber Sourcing Standard into ArcGIS version 10.4. For each survey year, mills that received their certification prior to the year of the survey were counted as certified. Mills that received their certification in the year of the survey were not counted until the next survey year. Buffers of 65 km (40 miles) and 80 km (50 miles) were created around each certified mill to reflect the sourcing radius and therefore, demarcate the size of the wood basket for each certified mill. We selected a 65 km sourcing radius as this is the minimum contractual sourcing radius across southern states (TimberMart-South, 2017). We selected a conservative 80 km sourcing radius of 87 km (54 miles) as it the historical average sourcing radius (2006–2017) across wood consuming mills in the US South (TimberMart-South, 2017). Additionally, we imported the location of survey sites present in the GFC's database for all the survey years (2002–2015) along with relevant attributes (total harvested area, distance of pre-existing roads, land ownership, physiographic region, terrain, and slope) into ArcGIS 10.4. Using the Spatial Analysis Toolbox in ArcGIS, we calculated the number of overlapping wood baskets at a survey site for a given survey year for the sourcing radius of 65 km first and then for 80 km.

The distribution of BMP implementation rates was not normal, so we used the non-parametric Wilcoxon signed-rank test to compare the mean implementation rates of survey sites within the sourcing radius of at least one certified mill versus outside of the sourcing radius of any certified mills. We used the Kruskal-Wallis test to compare the mean BMP implementation rates at survey sites across the different numbers of overlapping wood baskets at 65 and 80 km sourcing radii. Additionally, we developed two separate Tobit regression models (Tobin, 1958) to determine the influence of the total number of overlapping wood baskets on the mean BMP implementation rate at survey sites across years for selected sourcing radii. The use of a Tobit regression model is appropriate when a latent dependent variable is censored with many observations occurring at the limiting value. Without these censored limits on the dependent variable, the Tobit regression model is favorably comparable to the ordinary least squares (OLS) model. In our study, the use of the Tobit regression model was necessary because the BMP implementation rate on a surveyed harvest site is censored from both sides as the range of the variable is from 0% (lower limit) to 100% (upper limit) with clustering of observations at the upper limit constraint.

4. Results

The total land base in Georgia that fell within the sourcing radius of 65 km of certified mills nearly doubled from 6.3 million hectares (41% of total land) in 2002 to 12.5 million hectares (81% of total land) in 2015 (Table 1). For a sourcing radius of 80 km, this increase was from 8.6 million hectares (56% of total land) to 14.3 million hectares (93% of total land) over the same period. We also found that total land affected by the SFI Fiber Sourcing Standard is uniformly distributed across the state (Fig. 2). This is because forestlands in Georgia are well distributed across the state, and accordingly, wood consuming certified mills are also well dispersed.

We used National Land Cover Data for 2001, 2005, and 2011 for Georgia to estimate the influence of the SFI Fiber Sourcing Standard on the landscape. We found that the total forestland influenced by the SFI Fiber Sourcing standard increased over time (Fig. 3) due to an increase in certified wood consuming mills. In the year 2002, only about 4.0 million hectares of forestland (40.0% of total forestland) in Georgia were influenced by the SFI Fiber Sourcing Standard for a sourcing radius of 65 km, but in 2015 this went up to about 7.7 million hectares of

Table 1
Total land base in Georgia (million hectares) influenced by the SFI Fiber Sourcing Standard.

Survey year	Mills certified to the SFI Fiber sourcing standard prior to survey years (#)	Sourcing radius buffer (65 km)	Sourcing radius buffer (80 km)
2002	7	6.3 (41%)	8.6 (56%)
2004	8	7.6 (49%)	10.4 (68%)
2007	11	9.2 (60%)	11.9 (77%)
2009	19	10.9 (71%)	13.7 (89%)
2011	22	11.5 (75%)	13.9 (90%)
2013	24	12.1 (79%)	14.2 (92%)
2015	28	12.5 (81%)	14.3 (93%)

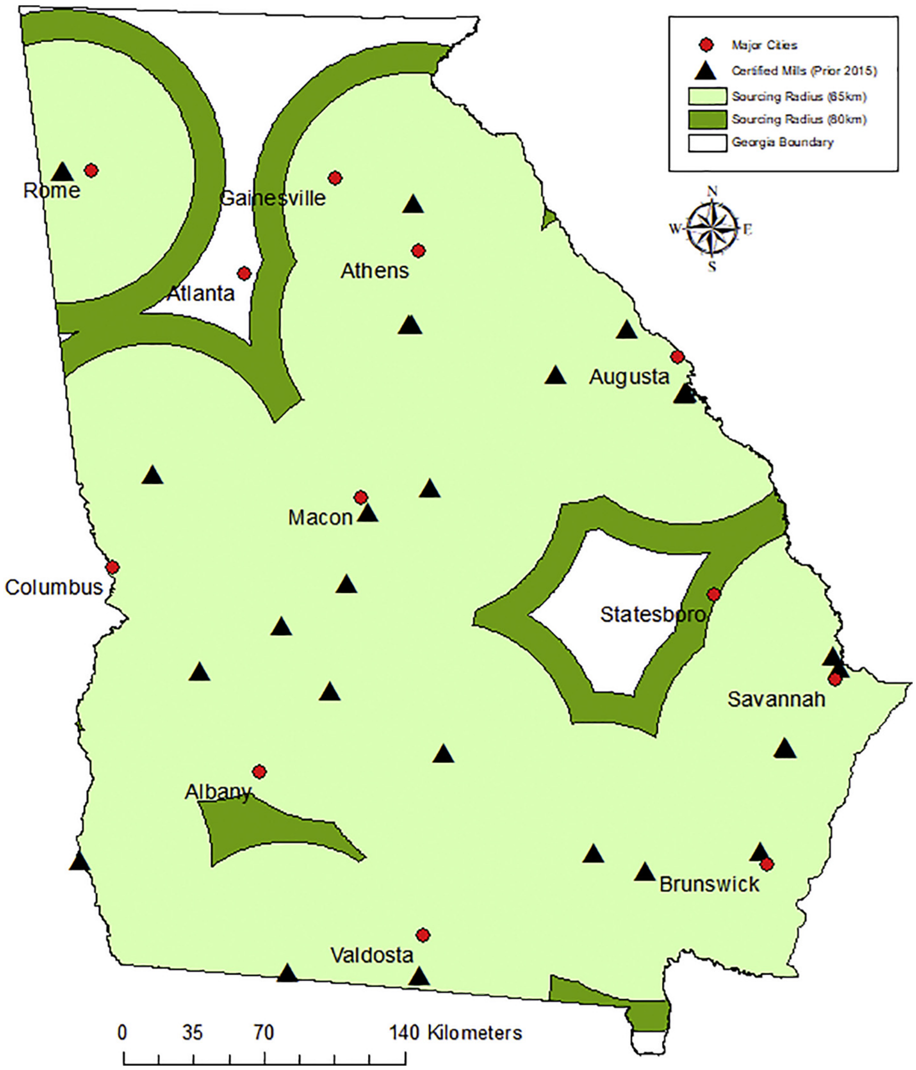

Fig. 2. Wood baskets of mills certified to the SFI Fiber Sourcing Standard prior to 2015.

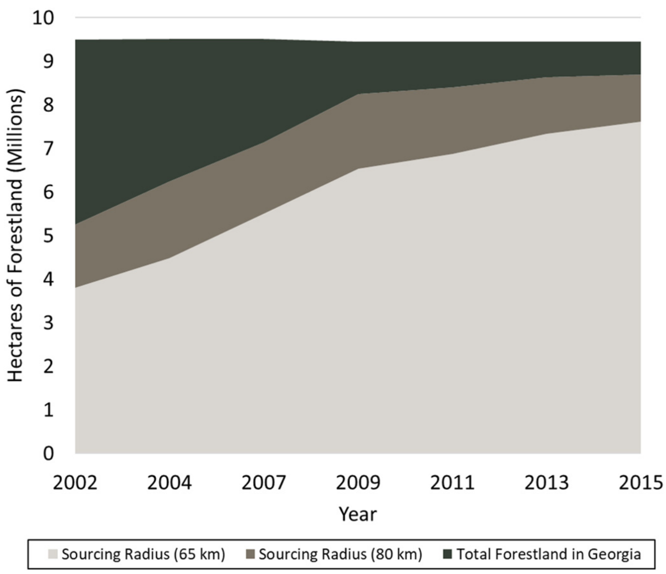

Fig. 3. Total forestland in Georgia affected by the SFI Fiber Sourcing Standard prior to 2015.

Table 2
Survey site count by year for 65 and 80 km sourcing radii. Yes: Within the fiber sourcing radius of at least one wood consuming mill certified to SFI Fiber Sourcing Standard. No: Outside of the sourcing radius. Percentage of total sites in each category for each year is in parentheses.

Survey year	# Survey sites	Within 65 km sourcing radius buffer		Within 80 km sourcing radius buffer	
		Yes	No	Yes	No
2002	314	142 (45%)	172 (55%)	195 (62%)	119 (38%)
2004	312	184 (59%)	128 (41%)	245 (79%)	67 (21%)
2007	334	211 (63%)	123 (37%)	269 (81%)	64 (19%)
2009	211	155 (73%)	56 (27%)	191 (91%)	20 (9%)
2011	182	136 (75%)	46 (25%)	172 (95%)	10 (5%)
2013	184	146 (79%)	38 (21%)	170 (92%)	14 (8%)
2015	187	162 (87%)	25 (13%)	178 (95%)	9 (5%)

forestland (80.6% of forestland). The percentage of Georgia's forestland affected by the SFI Fiber Sourcing Standard for a sourcing radius of 80 km has gone up from 55.4% in 2000 to 92.0% in 2015.

The percent of survey sites that fell within the 65 km sourcing radius of an SFI certified mill rose from 45% in 2002 to 87% in 2015 (Table 2). Similarly, the percent of survey sites that fell within the 80 km sourcing radius of an SFI certified mill rose from 62% in 2002 to 95% in 2015. This is attributable to the increasing number of wood mills (7 prior to

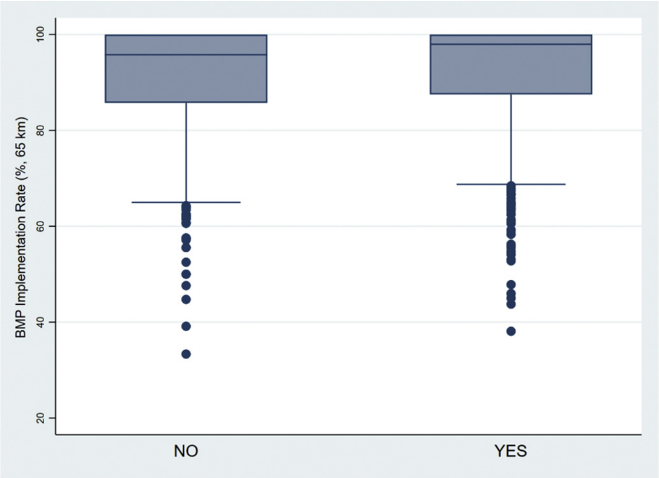

Fig. 4. BMP implementation rates on survey sites located inside and outside of a 65 km sourcing radius. Yes: Within the fiber sourcing radius of at least one certified mill. No: Outside the sourcing radius of any certified mill.

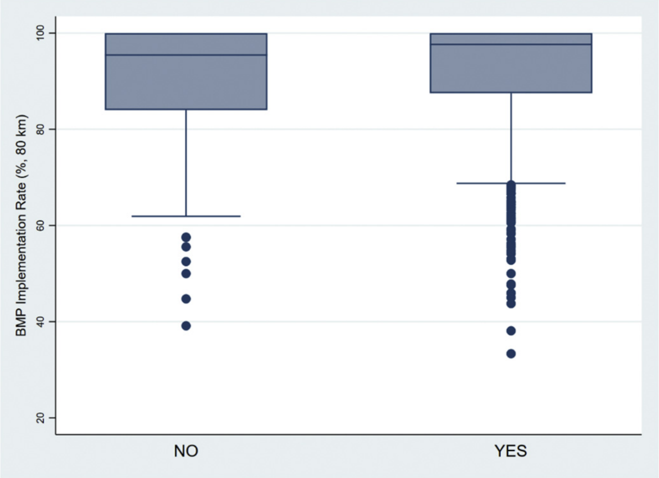

Fig. 5. BMP implementation rates on survey sites located inside and outside of 80 km sourcing radius. Yes: Within the fiber sourcing radius of at least one certified mill. No: Outside the sourcing radius of any certified mill.

2002 to 28 prior to 2015) certified to the SFI Fiber Sourcing Standard in Georgia.

For a 65 km sourcing radius, the mean implementation rate (92.3%) for survey sites located within the sourcing radius was statistically significantly different [$Z = -2.536$, $p = .012$] from the mean implementation rate (90.9%) for those survey sites located outside the sourcing radius (Fig. 4). For 80 km sourcing radius, we found a similar result where the mean implementation rate (92.1%) for survey sites located within the sourcing radius was statistically significantly different [$Z = -2.620$, $p = .009$] from the mean implementation rate (90.5%) for those survey sites located outside the sourcing radius (Fig. 5).

For a 65 km sourcing radius (Table 3), the mean BMP implementation rate across numbers of overlapping wood baskets differed statistically [χ^2 (5) = 11.866, $p = .0367$]. Similarly, the mean BMP implementation rate across the number of overlapping wood baskets differed statistically [χ^2 (6) = 14.960, $p = .0206$] for an 80 km sourcing radius (Table 4).

In the Tobit regression model, we included additional variables (Table 5) to determine their effects on the BMP implementation rate. We obtained selected variables from the GFC's Silvicultural BMP Implementation and Compliance Surveys. These surveys do not collect information on roundwood prices, logging crew training status, and final roundwood destination. As a result, we were unable to incorporate these variables into the developed regression models.

The results for a 65 km sourcing radius (Table 6) suggest that the BMP implementation rate decreases with an increase in harvest area. We also noticed that the expected BMP implementation rate would be lower by 9.5% on survey sites located on family forestlands relative to survey sites on public forestlands. Similarly, the expected BMP implementation rate would be lower by 6.9% and 8.4% on survey sites with rolling and steep terrain relative to flat survey sites, respectively. The number of overlapping wood baskets had a positive effect on the dependent variable (implementation rate), as the expected BMP implementation rate goes up with the rising numbers of overlapping wood baskets relative to the case when a survey site does not fall under the wood basket of any certified mill. For example, the expected BMP implementation rate was higher by 7.9% on survey sites having four or more overlapping wood baskets than survey sites that had zero overlapping wood baskets. We found similar results for an 80 km sourcing radius (Table 7).

For an 65 km sourcing radius, the average marginal effect analysis suggests the BMP implementation rate is higher by 3.9% for a survey site located within the wood baskets of four or more wood consuming mills certified to the SFI Fiber Sourcing Standard than a survey site not located within the wood basket of any mill certified to the same. Similar results were obtained for an 80 km sourcing radius (Table 8). We also estimated the average marginal effect of sites located or not located within the sourcing radii of 65 and 80 km on the implementation rate of BMPs. We found that the BMP implementation rate is higher by 2.01% [$Z = 3.62$, $p < .000$] for a survey site located within the 65 km sourcing radius of certified mills than a survey site not located within the wood basket of any certified mill for the same sourcing radius. The same effect for an 80 km sourcing radius was about 2.89% [$Z = 3.88$, $p < .000$].

Table 3
Count of survey sites by year and number of overlapping wood baskets for 65 km sourcing radius. Average BMP implementation rates are reported in parenthesis. The higher average BMP implementation rate with zero overlaps in 2013 is likely in large part due to a historic drought in Georgia in 2011 and 2012 that made it difficult to identify first-order streams at the time of harvesting. Additionally, sites with no overlaps were mostly located in those places (e.g., northern Georgia) were rainfall even in drought years was relatively higher than other locations within Georgia.

Survey year	0 Overlaps	1 Overlap	2 Overlaps	3 Overlap	4 Overlaps	5 Overlaps
2002	172 (85.5%)	120 (86.6%)	17 (93.1%)	5 (85.3%)		
2004	128 (90.4%)	160 (91.9%)	20 (90.0%)	4 (89.5%)		
2007	123 (94.6%)	152 (93.6%)	51 (90.1%)	7 (94.0%)		
2009	56 (95.6%)	73 (95.7%)	39 (92.7%)	32 (94.5%)	10 (93.6%)	1 (100.0%)
2011	46 (97.1%)	54 (95.3%)	45 (95.0%)	26 (96.9%)	11 (96.1%)	
2013	38 (93.1%)	61 (90.2%)	47 (91.0%)	23 (93.4%)	14 (91.3%)	1 (89.7%)
2015	25 (87.7%)	42 (93.2%)	60 (93.6%)	35 (91.4%)	13 (97.4%)	12 (92.0%)
Total	588 (90.9%)	662 (92.0%)	279 (92.3%)	132 (93.4%)	48 (94.5%)	14 (92.4%)

Table 4
Count of survey sites by year and number of overlapping wood baskets for 80 km sourcing radius. Average BMP implementation rates are reported in parenthesis.

Survey Year	Overlaps # 0	Overlaps # 1	Overlaps # 2	Overlaps # 3	Overlaps # 4	Overlaps # 5	Overlap # 6
2002	119 (86.3%)	149 (85.6%)	35 (88.9%)	11 (89.1%)			
2004	67 (91.3%)	194 (90.9%)	34 (91.2%)	17 (92.8%)			
2007	64 (95.2%)	155 (94.1%)	81 (92.4%)	24 (88.6%)	9 (92.2%)		
2009	20 (94.1%)	75 (95.9%)	46 (95.0%)	38 (92.7%)	20 (94.7%)	10 (97.1%)	2 (90.0%)
2011	10 (96.2%)	50 (96.8%)	50 (96.9%)	37 (96.1%)	20 (91.1%)	15 (95.7%)	
2013	14 (92.6%)	44 (92.8%)	56 (90.1%)	27 (92.5%)	28 (90.9%)	13 (92.3%)	2 (84.0%)
2015	9 (90.0%)	36 (92.2%)	38 (91.8%)	35 (93.1%)	25 (95.5%)	35 (92.5%)	9 (87.7%)
Total	303 (90.5%)	703 (91.6%)	340 (92.5%)	189 (92.7%)	102 (92.9%)	73 (93.8%)	13 (87.5%)

Table 5
Details of independent variables for Tobit regression models. The data is summarized for all the survey years. The sign (*) shows the reference category within a given variable.

Variables	Variable type	Harvested sites (#)	Mean BMP implementation rate	Mean
Harvest area	Continuous	1723		39.5 ha
Length of pre-existing streams	Continuous	1723		1.2 km
Ownership				
Family forest landowner	Dummy	1179	90.4%	
Public*	Dummy	104	94.9%	
Corporate/forest industry	Dummy	440	95.1%	
Physiographic region				
Lower coastal plain	Dummy	643	92.8%	
Mountains*	Dummy	126	91.2%	
Piedmont	Dummy	585	90.7%	
Ridge and valley	Dummy	20	92.0%	
Upper coastal plain	Dummy	349	92.3%	
Terrain				
Flat*	Dummy	712	93.7%	
Rolling	Dummy	953	90.5%	
Steep	Dummy	58	91.9%	
Slope				
Slight*	Dummy	1134	92.6%	
Moderate	Dummy	459	90.3%	
Severe	Dummy	130	90.8%	
Overlapping wood baskets (65 km)				
0*	Dummy	588	90.9%	
1	Dummy	662	92.0%	
2	Dummy	279	92.3%	
3	Dummy	132	93.4%	
≥3	Dummy	62	94.0%	
Overlapping wood baskets (80 km)				
0*	Dummy	303	90.5%	
1	Dummy	703	91.6%	
2	Dummy	340	92.5%	
3	Dummy	189	92.7%	
≥3	Dummy	188	92.9%	

5. Discussion and conclusion

The discourse about the sustainability of forestland revolves around the total land under sustainable forest management certification. It is typically assumed that certified forestland is the hallmark of sustainable forestry. This reasoning has led to a general perception that uncertified forestlands are unsustainably managed. In this regard, the role of the SFI Fiber Sourcing Standard becomes instrumental, as this standard is helpful in promoting sustainable forestry practices on uncertified forestlands, typically owned by families who do not have sufficient financial and technical resources for certifying their forestlands. Through the SFI Fiber Sourcing Standard, a family forest landowner can access the market, a wood mill can source sufficient wood from nearby forestlands, and most importantly, assurances of forest sustainability can be validated with reduced, or very little, financial burden on individual forest landowners. However, limited information is available about the influence of the SFI Fiber Sourcing Standard at a landscape level over space and time. For instance, there is no evidence linking the SFI Fiber Sourcing Standard with forestry BMP implementation rates in the United States.

Our results clearly demonstrate that, with respect to time, the total land (and forestland) affected by the SFI Fiber Sourcing Standard has gone up considerably in Georgia. This can be attributed to the rising number of wood-consuming mills certified to the SFI Fiber Sourcing Standard in Georgia. We also found that total land (and forestland) affected by the SFI Fiber Sourcing Standard is uniformly distributed across the state. The average BMP implementation rate is higher on survey sites located within the wood baskets of certified mills versus survey sites located outside the wood baskets of certified mills; thereby suggesting the private governance of forestry resources is making a positive impact in ensuring the sustainability of forest resources in Georgia. This is attributed to the fact that a certified mill could discontinue purchasing roundwood from a logger who does not follow BMPs. Additionally, the BMP implementation rate is closely monitored not only by the third-party auditors at the time of inspection but also by mill foresters. In the case of any non-compliance, suitable measures are taken to remediate issues related to BMP non-compliance. Therefore, our results are supportive of anecdotal evidence and existing perceptions among forestry stakeholder groups about the positive role of the SFI Fiber Sourcing Standard on forestry BMP implementation rates in Georgia.

The average BMP compliance rate of survey sites within the wood baskets of certified mills was higher by about 2% relative to surveyed sites located outside of the wood basket of uncertified mills over a period of 14 years (2002 to 2015) for a sourcing radius of 65 km. This low percentage difference can be explained by two major factors. First, we did not include GFC's survey data for 1991, 1992, and 1998 in this analysis because of missing data (1991 and 1992) and comparability issues (1998). There were no mills in Georgia certified to the SFI Fiber Sourcing Standard until the late 1990s and the average BMP implementation rate in the state was < 80% prior to the 2000s. The three missing survey years (1991, 1992, and 1998) would have provided pre- and post-certification perspectives as well as covered a period during which the most dramatic implementation rate increases were occurring. Second, Georgia started tracking BMP implementation rates in the early 1990s which itself could have had promoted higher BMP compliance rates prior to the introduction of the SFI Fiber Sourcing Standard. Therefore, the observed difference of 2% since 2002 between survey sites located within and outside of a 65 km sourcing radius of certified mills is reasonable.

We acknowledge that a high rate of forestry BMP implementation is

Table 6
Results of Tobit regression model assuming a sourcing radius of 65 km.

Variables	Coefficient	Standard Error	T	P > |t|	[95% Conf. Interval]	
Harvested area	−0.046	0.010	−4.42	0.000	−0.066	−0.026
Ownership (family landowners)	−9.471	1.095	−8.65	0.000	−11.619	−7.323
Terrain (rolling)	−6.946	1.004	−6.92	0.000	−8.917	−4.977
Terrain (steep)	−8.359	2.599	−3.22	0.001	−13.456	−3.261
Number of overlaps						
1	3.127	1.120	2.79	0.005	0.930	5.324
2	3.562	1.431	2.49	0.013	0.754	6.371
3	5.387	1.962	2.75	0.006	1.538	9.234
> 3	7.985	2.742	2.91	0.004	2.606	13.365
Constant	108.685	1.399	77.71	0.000	105.942	111.428

Number of observations 1723, Uncensored 907, Left-censored 0, Right censored 816.
LR χ^2 (8): 142.41, prob. > χ2 0.000, Pseudo R2 0.0157.

Table 7
Results of Tobit regression model assuming a sourcing radius of 80 km.

Variables	Coefficient	Standard error	T	P > |t|	[95% Conf. interval]	
Harvested area	−0.045	0.010	−4.33	0.000	−0.065 -0.025	
Ownership (family landowners)	−9.473	1.096	−8.64	0.000	−11.622	−7.323
Terrain (rolling)	−7.271	1.017	−7.15	0.000	−9.266	−5.275
Terrain (steep)	−9.075	2.609	−3.48	0.001	−14.192	−3.958
Number of overlaps						
1	4.292	1.358	3.16	0.002	1.629	6.957
2	5.672	1.558	3.64	0.000	2.616	8.727
3	6.074	1.847	3.29	0.001	2.452	9.697
> 3	6.395	1.857	3.44	0.001	2.753	10.04
Constant	107.102	1.557	68.76	0.000	104.046	110.157

Number of observations 1723, Uncensored 907, Left-censored 0, Right censored 816.
LR χ^2 (8): 144, prob. > χ^2 0.000, Pseudo R^2 0.0159.

Table 8
Average marginal effect of numbers of overlapping wood baskets of wood-consuming mills certified to the SFI Fiber Sourcing Standard on the probability of BMP implementation rate.

Number of overlaps	Coefficient	Standard error	T	P > |t|	[95% Conf. interval]	
Sourcing radius (65 km)						
1	1.710	0.614	2.78	0.005	0.505	2.914
2	1.931	0.758	2.55	0.011	0.445	3.417
3	2.816	0.954	2.95	0.003	0.946	4.686
> 3	3.954	1.173	3.37	0.001	1.655	6.254
Sourcing radius (80 km)						
1	2.453	0.799	3.07	0.002	0.886	4.019
2	3.158	0.874	3.61	0.000	1.444	4.871
3	3.356	0.995	3.37	0.001	1.406	5.306
> 3	3.511	0.991	3.54	0.000	1.569	5.453

Note: Changes in factor levels is the discrete change from the base level.

not an absolute, but rather a robust, indicator of forest sustainability. More research is needed to identify similar measures in ascertaining the influence of the SFI Fiber Sourcing Standard for sustainable forest management. In this study, we focused on mills certified to the SFI Fiber Sourcing Standard and sourcing within Georgia. In the future, it would be beneficial to take a region-wide approach to explore further the effect of the SFI Fiber Sourcing Standard on the forestry BMP implementation rate. We expect that our results will provide insights on the positive role of the SFI Fiber Sourcing Standard on forestry BMP implementation rates in Georgia. We believe that our results will also help other southern states sharing similar landownership patterns, policy landscapes, and roundwood market conditions. We also hope that standards like the SFI Fiber Sourcing Standard could become a mechanism for bringing the landscape perspective into conservation partnerships across the globe.

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Conflict of Interest

Authors declare no conflict of interest.

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