



How do landowners perceive and respond to incentives for sustainable forest management? A synthesis to inform discussions on programs for climate-smart forestry

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ABSTRACT

Originally, forest sustainability was primarily concerned with continual timber production. Contemporary concepts such as sustainable forest management (SFM) and climate-smart forestry (CSF) emphasize the continual production of multiple forest goods and services, both market and non-market. In addition to the creation of new programs for CSF, recent legislation in the United States (US) has expanded the use of incentive programs traditionally used for subsidizing SFM to also support management activities that aid in climate adaptation and mitigation. Understanding landowner perceptions of incentive programs for SFM in the US and how their use correlates with landowner behavior may be informative for discussions on programs for CSF. In this study, we systematically review the literature on financial incentive programs for SFM and forest landowner behavior, perceptions, and characteristics. We restrict our analysis to refereed articles published in academic journals since 1992 and which feature actual incentive programs available to forest landowners in the US. We synthesize lessons from the literature on past and current programs and discuss potential implications for incentive programs for CSF. Program administrators may utilize the findings from this review to inform the design and administration of incentive programs that promote sustainable forestry and support forest landowners in responding to and mitigating climate change.

1. Introduction

The concept of forest sustainability has evolved over time but emerged as both a biological and socioeconomic notion centered on production (Sample and Sedjo, 1996; Rodriguez Franco and Conje, 2023; Cooper and MacFarlane, 2023). In the late 1980s and early 1990s, momentum from the international forestry community led to the development of performance standards and indicators for sustainable forest management (SFM), a term originating from sustainable development and the three pillars of sustainability: Economic, social, and environmental (Wang, 2004; McGinley and Cabbage, 2020). SFM expanded the focus of forest sustainability beyond continual production of biological and socioeconomic benefits of forests, incorporating the production of ecological, environmental, cultural, and spiritual benefits

for current and future society (United Nations [UN], 1993; Rodriguez Franco and Conje, 2023).

In the 21st century, the concept of climate-smart forestry (CSF) arose from climate-smart agriculture, an approach to achieve sustainability in the agricultural sector in response to climate change (Nabuurs et al., 2015, 2018; Lipper and Zilberman, 2018; Bowditch et al., 2020). In the context of European mountain forests, CSF has been defined as “sustainable adaptive forest management and governance to protect and enhance the potential of forests to adapt to, and mitigate climate change” and with the goal of sustaining “ecosystem integrity and functions” (Bowditch et al. 2020, p. 8). The United States Department of Agriculture defines climate-smart agriculture and forestry jointly as an integrated approach that facilitates landowners in addressing climate change through mitigation and adaptation strategies which also sustain

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productivity and incomes from farming, ranching, and forestry (United States Department of Agriculture [USDA], 2023).

Recent studies have highlighted the similarities between SFM and CSF (Bowditch et al., 2020; Cooper and MacFarlane, 2023). Cooper & MacFarlane (2023) proposed that SFM is one of three components of CSF, along with restoration and avoided conversion. To address the current emphasis in achieving climate-smart outcomes through forestry in the United States (US) (USDA, 2022; White House, 2022), public programs that had been incentivizing SFM recently began incentivizing landowners to implement practices that support CSF (Inflation Reduction Act, 2022; Natural Resources Conservation Service [NRCS], 2024b; USDA, 2024a). Furthermore, new public programs (USDA, 2024b; United States Forest Service [USFS], 2024) and market-based mechanisms (Shen et al., 2023) have been created to subsidize and/or promote CSF.

As such, there is a timely need to understand how forest landowners have perceived and responded to different types of financial incentives for SFM in the US. Themes and trends gleaned from the literature on financial incentives for SFM may have important implications for current and emerging programs for CSF. This study addresses the following research questions: (1) How have landowners responded or behaved in relation to incentives for SFM? (2) What are landowners' attitudes toward incentives for SFM? (3) How are landowners that use or do not use financial incentives for SFM characterized? (4) What lessons can we learn from the literature to inform discussions on incentives for CSF? In order to answer these questions, we reviewed the academic literature on financial incentives for SFM in the US and landowner behaviors, perceptions, and characteristics.

Our synthesis differs from past review studies through its comprehensive scope with respect to the research questions addressed, inclusion of qualitative and quantitative analyses, geographic coverage, and financial incentive instruments represented (Amacher et al., 2003; Beach et al., 2005; Floress et al., 2019; Chizmar et al., 2021; Mitani and Lindhjem, 2022; Butler et al., 2023). We also incorporated the recommendations of Mitani and Lindhjem (2022) into our approach by focusing on research that investigates landowners' use and perceptions of actual incentives and not hypothetical programs, as the researchers found that participation in forest incentive programs was estimated to be higher on average for hypothetical programs compared to actual programs and actions. The remainder of the paper is structured as follows: Section 2 provides background on the evolution of the concept of forest sustainability over the past four centuries and the role of financial incentives in supporting SFM and CSF; Section 3 presents our approach to identifying, screening, and reviewing the academic literature; Section 4 includes summarized results from the analysis of the literature; Section 5 discusses the themes, trends, and lessons gleaned from the literature; and Section 6 provides concluding remarks.

2. Background

2.1. Forest sustainability through time

Documents dating back to the 17th century discuss the negative implications of past forest resource use and the importance of being able to utilize the resource continually for the benefit of future generations (Wiersum, 1995). Up until the mid-20th century, sustainability of forests was embodied by the principle of sustained yield, the balancing of forest harvests and growth to ensure continual growth and production (Sample and Sedjo, 1996; Luckert and Williamson, 2005), and the normal forest concept, a forest with multiple even-aged, equal-sized stands representing each age class to maximize continual production (Leslie, 1966; Rodriguez Franco and Conje, 2023). During the middle of the last century, forest sustainability in the US expanded from a primary focus on the production of wood products to the continual production of multiple forest benefits including timber, fish and wildlife, recreation, range and fodder, and watershed protection (Leslie, 1966; Rodriguez Franco and

Conje, 2023). In subsequent decades, the scope of forest sustainability broadened to the model of sustainable forest management, which includes a broad range of benefits from forests, an emphasis on the health of forest ecosystems, and an intention to adapt management as needed (Luckert and Williamson, 2005; Rodriguez Franco and Conje, 2023).

SFM was placed on the international agenda during the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, which adopted the Rio Forest Principles, provided an aspirational momentum, and set in motion the Montreal Process and related initiatives on SFM (McGinley and Cubbage, 2017; Rodriguez Franco and Conje, 2023). The definition of SFM has evolved since the mid-1990s but has clearly maintained an emphasis on balancing the economic, social, and environmental values of forests for the benefits of current and future generations (Table 1). Forums, such as the Montreal Process, the Lepaterique Process for Central America, the Pan-European Forest Process, and the Sustainable Forest Initiative have formulated guidelines, specific criteria and indicators for assessing SFM (e.g., conservation of biodiversity, maintenance of forest productivity, forest health, soil and water resources, and contribution to the global carbon cycle, among others) (McGinley and Cubbage, 2017). A common theme of these guidelines is a focus on multiple forest values and informal voluntary participation in SFM practices (e.g., forest certification).

In recent years, researchers have argued that CSF has a foundation in SFM but expands the emphasis on climate adaptation and mitigation and ecosystem services (Verkerk et al., 2020; Wang, 2024). Accordingly, many SFM practices may also be used to support climate-smart outcomes related to climate mitigation and adaptation (Table 2). As such, both Bowditch et al. (2020) and Santopuoli et al. (2021) sought to develop criteria and indicators for CSF based on the pan-European criteria and indicators for SFM that address adaptation and mitigation. Bowditch et al. (2020), who established the framework, utilized SFM indicators as a basis for CSF due to the concepts' mutual inclusion of multiple forest benefits and ecosystem services. Cooper and MacFarlane (2023) proposed re-framing CSF from its focus on SFM, production forestry, and carbon to a broader framework that also includes restoration and avoided conversion and prioritizes all forest values and ecosystem services.

2.2. Incentives for sustainable forest management

Not all goods and services produced by forests and woodlands are captured through financial markets (Chizmar, 2021; Frey et al., 2021). As such, if a landowner self-optimizes, maximizing benefits with respect to costs, this could lead to the sub-optimal production of these non-market forest goods and services at the societal level (Ollikainen, 2016). More specifically, without incentives, the market prices associated with wooded lands and wood products may not fully capture and internalize the costs and benefits associated with non-market goods and services such as biodiversity, flood control, aesthetics, and soil retention (Baumol and Oates, 1988; Frey et al., 2021). Public financial incentive programs and market-based mechanisms are two types of interventions which either decrease the value of costs or increase the value of benefits from forest management and protection (McGinley and Cubbage, 2020).

Financial incentives for forest management have generally taken two forms: tax benefits and direct payments. Landowners may qualify for income tax deductions, credits, and amortization and preferential property tax programs. Landowners may receive one-time direct payments, such as cost-share reimbursements, or periodic payments, such as in the case of conservation easements or payments for ecosystem services including forest carbon. Each of these incentive types attempt to encourage landowner behavior and practices that support the provision of non-market benefits of forests (McGinley and Cubbage, 2020; Chizmar et al., 2021; Frey et al., 2021). Landowners may also participate in market-based incentive programs such as carbon markets through the sale of carbon offsets or credits, tradeable certificates that represent additional and permanent greenhouse gas emission reductions or

Table 1
Common definitions of sustainable forest management over time.

Organization	Time	Definition
International Tropical Timber Organization (ITTO)	1992	"The process of managing forest to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment".
Rio Forest Principles – UN Conference on Environment and Development	1992	"Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural, and spiritual needs of present and future generations. These needs are for forest products and services, such as wood and wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks, and reservoirs, and other forest products. Appropriate measures should be taken to protect forests against harmful effects of pollution, including air-borne pollution, fires, pests, and diseases, to maintain their full multiple values. "
Montreal Process on Temperate and Boreal Forests	1993–1995	"A way to maintain forests' critical functions and characteristics for current and future generations: carbon cycles, forest health, water and soil protection, biodiversity, and forest productivity."
Sustainable Forestry Initiative (SFI)	1994	Sustainable forestry is: "To meet the needs of the present without compromising the ability of future generations to meet their own needs by practicing a land stewardship ethic that integrates reforestation and the managing, growing, nurturing, and harvesting of trees for useful products and ecosystem services such as the conservation of soil, air and water quality, carbon, biological diversity, wildlife and aquatic habitats, recreation and aesthetics."
United Nations Forest Instrument	2007	"A dynamic and evolving concept [that aims] to maintain and enhance the economic, social, and environmental values of all types of forests, for the benefit of present and future generations."
Food and Agriculture Organization (FAO)	2024	"The aim of sustainable forest management (SFM) is to ensure that forests supply goods and services to meet both present-day and future needs and contribute to the sustainable development of communities." "SFM encompasses the administrative, legal, technical, economic, social and environmental aspects of the conservation and use of forests. It implies various degrees of human intervention, ranging from actions aimed at safeguarding and maintaining forest ecosystems and their functions to those favouring specific socially or economically valuable species or groups of species for the improved production of goods and services."

Sources: [Sustainable Forestry Initiative, 2015](#); [UN, 2016](#); [Montreal Process Working Group, 2023](#); [Rodriguez Franco and Conje, 2023](#); [Food and Agriculture Organization, 2024](#); [International Tropical Timber Organization, 2024](#).

Table 2
Forest management practices and examples of potential benefits to sustainable forest management and climate-smart forestry.

Practice	Sustainable Forest Management	Climate-Smart Forestry
Treatment of slash and down woody debris	Mechanical removal of slash and debris	Controlled retention of down woody debris to enhance soil moisture
Herbicide application	Application of herbicide to prevent encroachment of competitive, non-desired species	Application of herbicide to prevent encroachment of competitive, non-desired species
Tree establishment	Planting of species best suited for site	Planting of species that are expected to be resilient to future conditions
Prescribed fire	Controlled burning to create wildlife habitat	Controlled burning to reduce fuel loads
Mechanical thinning	Reduce forest density to promote growth of desired stems	Decrease forest density to reduce drought-related stress and mortality
Selective harvesting	Perform shelterwood or seed-tree harvest to retain trees of good form and vigor	Perform shelterwood or seed-tree harvest to retain trees that were resistant to pest or disease outbreak
Riparian buffer establishment	Establish and maintain tree and ground cover in areas adjacent to water bodies to protect water quality	Establish and maintain tree and ground cover in areas adjacent to water bodies to store carbon

Note: This is an illustration of forest practices that can promote outcomes relevant to the paradigms of sustainable forest management and climate-smart forestry. Due to similarities between sustainable forest management and climate-smart forestry, outcomes listed under one paradigm may also qualify for the other paradigm.

Sources: [Chizmar and Parajuli, 2022](#); [Gagnon, 2022](#); [Natural Resources Conservation Service, 2024a, b](#); [Swanston et al., 2016](#).

removals that are real and measurable ([Ruseva et al., 2017](#)).

The US has been a leader in SFM evidenced by relatively stable forest land area and consistently high volume of timber production ([McGinley and Cabbage, 2020](#); [Rodriguez Franco and Conje, 2023](#)). In the US, forest sustainability has been promoted by a variety of public and private incentive mechanisms, including financial assistance, tax benefits, payments for ecosystem services, and carbon offset programs ([Table 3](#)). More recently, forests and wood products have become integral to broader conversations about solutions to climate change (i.e., CSF),

Table 3
Types of incentive mechanisms used to encourage sustainable forest management.

Incentive Type	Mechanism	Description
Tax Benefit	State property tax incentives Federal and state income tax provisions	Reduced property tax liability for forestlands Deduction of forest management expenses, reforestation cost deduction and amortization
Direct Payments	Conservation easement Cost-share reimbursement Payment for ecosystem services	Payment for lands enrolled in a conservation easement Reimbursement payment for the costs of management practices Periodic payment for production of ecosystem services such as for wildlife habitat and/or water quality
Carbon markets (voluntary and compliance)	Forest carbon offset programs and markets	One-time and/or periodic payments for carbon sequestered through forest management activities

resilience building, job training, and enhancing land retention and access to forest assistance programs, especially among underserved landowner groups (veteran, African American, and tribal forest owners). New federal initiatives focused on forest management for climate benefits have received support from the 2022 Inflation Reduction Act for a suite of incentive mechanisms targeted at private forest owners. However, policy certainty and predictability remain a concern among both implementing entities and landowners looking to engage in incentive programs (Forest Landowners, 2024). Understanding the relationship between types of incentive mechanisms and landowner behavior is, thus, essential for informing policy decisions and development of

programs incentivizing SFM and CSF. It is this consideration that provides one of the motivations for this review, namely assessing existing empirical knowledge on financial incentives for SFM, and how landowners have responded to these incentives.

3. Methodology

Following Xiao and Watson (2019), our approach was guided by our study motivation to inform discussions on incentive programs. We developed and refined our research questions based on conversations with forest incentive program and woodland owner outreach specialists

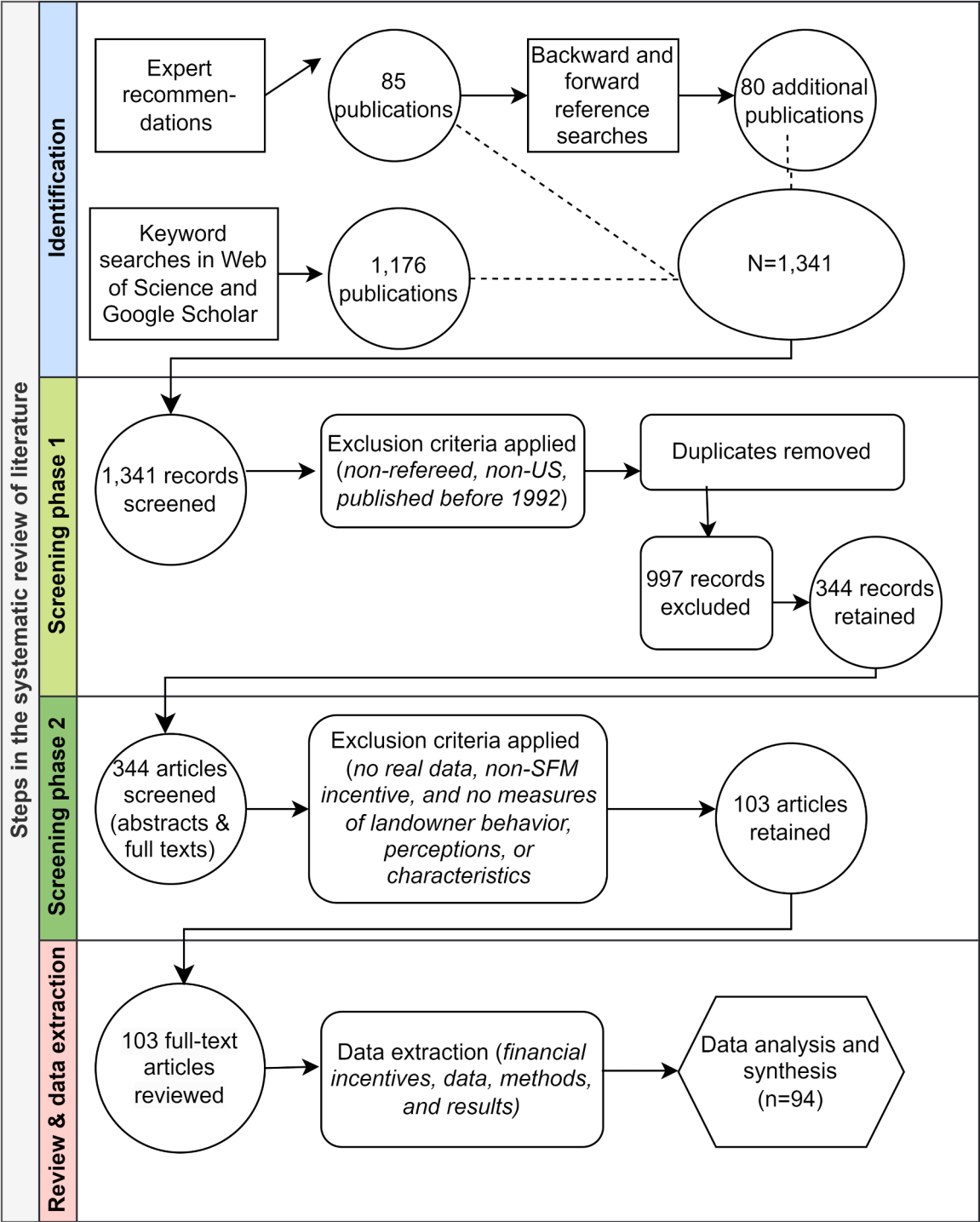


Fig. 1. Steps in the systematic review of literature.

and their research needs related to incentive programs for forest carbon management (D. Cleaves and M. Megalos, personal communication, November 2022 – July 2023). The specialists we consulted were interested in understanding the extent of the knowledge on financial incentive programs for forest landowners in the US. In order to address our four research questions, we determined that a hybrid testing-extending review approach would be the most appropriate. In simple terms, a testing review aims to address a specific question, whereas an extending review seeks to create higher-order constructs based on concepts explored in the literature (Xiao and Watson, 2019).

Our review of the literature involved identification of relevant publications, screening for eligibility (phase 1), screening for relevance (phase 2), review and data extraction, and synthesis (Fig. 1). This study utilized three different methods of identifying literature: (1) Recommendations from experts, (2) backward and forward search, and (3) literature database search. First, we asked experts in forest taxation and extension to share citations for publications related to forest incentive programs and landowner behavior in the US. The request for literature from experts was broad: Journal articles and other publications published in the last 50 years (1973–2023) that feature forest incentive programs available to landowners in the US and explore forest landowner behavior. Further, the request was not restricted to incentive programs for sustainable forest management, as this was included following identification of literature as an inclusion criterion in the second screening phase. We collected citations for 85 publications from both academic and gray literature based on the input from topical experts. Of note, we later exclude gray literature from the review but included it in the literature pools prior to applying exclusion criteria as these publications may cite or be cited by relevant formally refereed publications.

Second, we performed backward and forward reference searches to identify additional publications from gray and academic literature. Backward searches were performed by reviewing the references cited in the 85 publications suggested by experts. Meanwhile, we utilized Google Scholar to complete forward searches for articles that cited any of the 85 articles in the expert literature pool. Through backward and forward searches, we catalogued 80 additional publications. Finally, we searched for publications in Google Scholar and Web of Science. We collectively and iteratively identified keywords to utilize in literature searches that would capture various types of incentives for forest landowners (Table 4). Since we screen for relevance to SFM in the second screening phase, we did not include a search term related to “sustainability” or “sustainable forest management.” After we created a list of search terms and synonyms associated with financial incentives and forest landowner behaviors and attitudes, we tested combinations of the keywords to evaluate their ability to return relevant results. We documented citations for all observations associated with these searches and noted duplicate results. After testing of keywords, we created more complex search phrases using Boolean operators and screened the first 100 results, continuing to note duplicates. Including duplicates, we recorded an additional 1176 publications from the literature database search.

Table 4
Keywords used in literature database searches.

Incentive	Landowner	Response
(Forest) incentive	(Forest) landowner	Behavior
Tax incentive	(Family) forest owner	Perception
Cost share	Woodland owner	Attitude
(Forest) carbon market	Nonindustrial private forest landowner	
(Forest) carbon offset		
(Forest) carbon credit		
Payment for ecosystem service		
Carbon payment		
Carbon program		
Conservation easement		

Between the three pools of literature, we collected 1341 publications.

3.1. Inclusion and exclusion criteria

We developed a screening protocol through an iterative process where we tested the protocol with ten articles selected to capture diversity in the literature sample. We refined the protocol to encourage consistency in coding and interpretation of inclusion and exclusion criteria. The screening protocol was divided into two phases, screening for eligibility and screening for relevance (Supplement 1). For the initial screening phase of the literature identified through the database search, we reviewed citations and excluded those published prior to 1992 or not focused on the US or a portion of the US, when evident from the citation. We chose the year 1992 due to the occurrence of the Rio Conference, or Earth Summit, which some authors have distinguished as influential and proliferating conversations on how the world should sustainably manage and protect forests to meet current and future needs (Bulkan et al., 2010; Bastrup-Birk et al., 2016; Gillespie, 2017; McGinley and Cubbage, 2017; Rodriguez Franco and Conje, 2023). We constrained our sample to formally refereed journal articles as a means to control for quality and reduce the inclusion of studies that were also published in journals and theses, dissertations, or other reports. We also removed duplicates from the literature database search during this initial phase. As a result, we excluded 922 publications from the literature search pool, leaving 254 publications in the respective pool. We utilized the same exclusion criteria to refine the expert and backward-forward search literature pools. This led us to remove 11 citations from the original expert pool and 10 citations from the backward-forward search pool. Finally, we merged our three pools of literature and dropped 54 duplicates. In total, we excluded 997 publications in the first part of the screening phase, leaving a total of 344 publications.

In the second part of the screening phase, we reviewed abstracts, and scanned the full-text of articles when necessary for the 344 publications identified in the first phase. Studies were excluded if (1) they did not use real data, as opposed to simulated data, collected by program administrators or through qualitative or quantitative research approaches such as surveys, focus groups, or interviews to assess landowner response, attitudes, or characteristics relating to financial incentives; (2) the incentive instrument analyzed does not subsidize SFM, where SFM is defined as an approach to ensure forests continually produce goods and services to benefit the needs of present and future generations, encompassing a spectrum of management activities and intensity and some level of human intervention (Food and Agriculture Organization, 2024); or (3) they did not report landowner behavior responses, perceptions, or characteristics as they pertain to financial incentives. For the purpose of this study, we interpreted a landowner behavioral response as forest management activities and other forestry-related behaviors correlated with the use of forest landowner incentives, including implementing silvicultural and conservation practices, planning of activities, and use of other incentives. After the second part of the screening phase, we were left with 103 articles to review.

3.2. Data extraction and analysis

We designed our review protocol to facilitate analysis of both quantitative and qualitative research. Similar to the approach for creating the screening protocol, we tested the review protocol and updated it to improve interpretation and consistency between the coders. When reviewing the full text of articles, we removed nine additional studies that did not meet the inclusion criteria (e.g., featured hypothetical incentive programs, did not analyze landowner behaviors, perceptions, or characteristics). For the remaining 94 articles, we extracted information related to the financial incentive(s) analyzed in the study, the data and method(s) utilized, and the results as they relate to landowner behaviors, perceptions, and characteristics (Supplement 2). We synthesized the findings according to trends and themes among

behaviors, perceptions, and characteristics of landowners and summarize them below with respect to each research question.

4. Results

Over half of the 94 studies selected for this review were published in the 2010s (Fig. 2, Supplement 3). We identified seven types of incentives analyzed in the literature: Cost-share, property taxes, conservation easements, carbon offsets, income tax provisions, a mix of programs, and other. Fig. 3 summarizes the number of studies that explored incentives by type and scope, i.e., level at which the incentive program is administered (e.g., state, federal, non-profit). Over a third of the articles examined a combination of incentives with a mixed (25 studies), federal (9 studies), or state (2 studies) scope of implementation. Financial incentives commonly analyzed in the literature were cost-share (18 studies), property tax (15 studies), conservation easement (10 studies), and carbon offset programs (9 studies).

The majority of studies (65 of 94) employed quantitative methodologies utilizing survey, administrative, or other types of data (Fig. 4). Qualitative research largely relied on interviews, while mixed-methods studies used focus groups, interviews, and a mix of other data sources. Fig. 5 summarizes the number of studies that analyzed landowner behaviors, perceptions, and characteristics by incentive type. Overall landowner behavior and characteristics are the most commonly examined constructs in the literature (56 and 48 studies respectively), followed by landowner perceptions (41 articles). Among the publications examining a mix of incentives, 19 focused on behaviors, 19 on perceptions, and 17 on landowner characteristics.

4.1. Question 1: How have landowners responded or behaved in relation to incentives for SFM?

Almost half of the studies that evaluated landowner behaviors were published in the last decade (26 of 56). One-fourth of the studies (14 of 56) were published in the 2020s, and the remainder was equally distributed between the 1990s (8 of 56) and 2000s (8 of 56). Fig. 5 shows the distribution of behavior studies by type of incentive: The majority focused on mixed incentives (19 studies), cost-share programs (14), property tax programs (10 studies), and conservation easement programs (6). Behavior studies primarily used quantitative research approaches (48 of 56), followed by mixed approaches (7 of 56), and qualitative methods (1 of 56). Survey data was most often utilized in behavior literature (43 of 56).

Overall analysis of landowner behavior showed a mixed behavioral pattern influenced by cost-share, preferential property tax, and conservation easement programs as well as other financial and technical assistance programs related to engagement in active forest management.

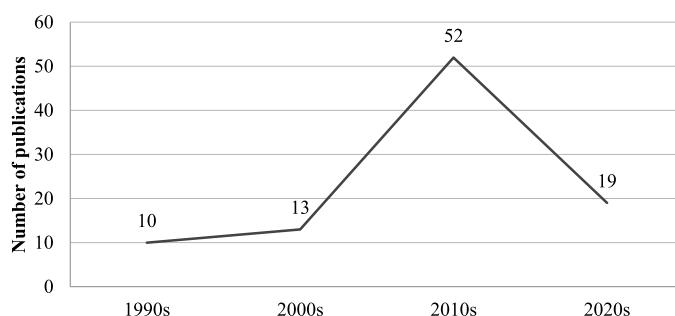


Fig. 2. Number of publications included in the analysis by decade. The category ‘other’ programs include one block grant and one unknown program with an unknown scope; one conservation easement with no specified scope; and two programs related to the Minnesota Sustainable Forest Incentives Act.

Landowner responses to cost-share programs

Butler et al. (2014) found that landowners who received assistance through cost-share programs were more likely to have forest management plans and engage in activities such as tree planting, wildlife habitat improvement, fire hazard reduction, and afforestation and harvesting activities than those who did not receive assistance. Another study by Kilgore et al. (2015) supported this finding, additionally revealing that such landowners were more likely to have established conservation easements and were more concerned about keeping their land intact for future generations. Similarly, Song et al. (2014b) highlighted the effectiveness of the cost-share program in promoting better forest management by showing that program participants were more actively involved in silvicultural and conservation activities compared to non-participants.

In the southern pine region, landowners’ demand for planting was positively correlated with cost-share assistance for planting costs (Hardie and Parks, 1996). Specifically, in North and South Carolina, awareness of cost-share programs was positively correlated with reforestation decisions and investments, whereas the actual use of these programs was negatively correlated with reforestation investments (Zhang and Flick, 2001). For landowners who had pre-conceived land management goals, participation in cost-share programs was also found to reinforce their stewardship behavior (Andrejczyk et al., 2016).

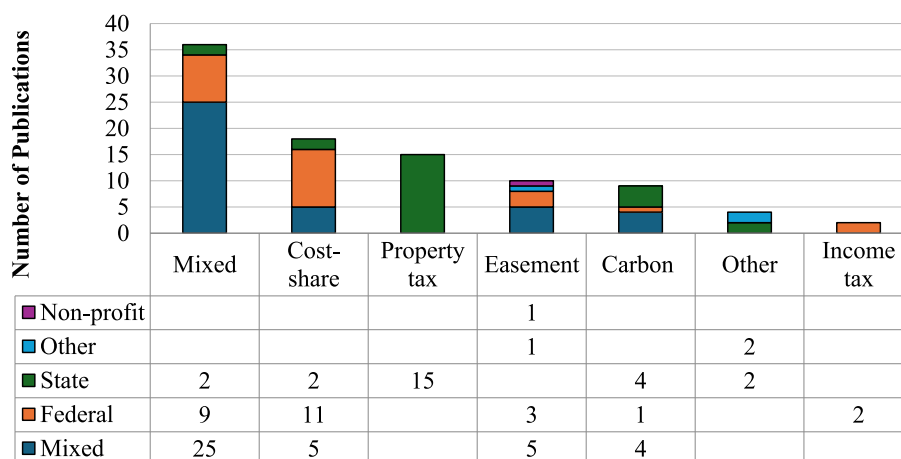
Responses to preferential property tax programs

Ma and Kittredge (2011) found that both engaged (enrolled) and unengaged (unenrolled) landowners under state preferential property tax programs may consider donating or promoting conservation easements, conditional on the experience with cooperative forest management or cross-boundary cooperation with adjacent landowners. Along the same line, Brockett et al. (2003) observed no meaningful differences in behavior between participants and non-participants of Tennessee’s preferential property tax program concerning future land use and the program’s land conversion objectives. Similarly, Brockett and Gebhard (1999) observed no significant relationship between enrollment in Tennessee’s preferential property tax program and forest management practices. However, Indiana landowners with larger acreages enrolled in property tax programs had completed more conservation management strategies and were more likely to grant conservation easements (Farmer et al., 2016; J.R. 2017).

Several studies suggested that factors beyond the lower tax rates offered through the property tax incentive programs could have influenced management intensity and participation in these programs (Rathke and Baughman, 1996; Meier et al., 2019; Schram et al., 2021). For example, Rathke and Baughman (1996) argued that the requirement of a management plan for enrolling in Minnesota’s property tax program may have impacted management activities, such as tree planting and timber stand improvements. Schram et al. (2021) made a similar argument, noting that the requirement of a management plan in Michigan combined with factors such as forest type, size, and condition, likely played a significant role in shaping forest management activities. In contrast, Kilgore et al. (2008a, 2008b) revealed that Minnesota landowners’ willingness to enroll in the Sustainable Forest Incentive Act program was not an indicator of past or future forest management activities.

Responses to conservation easement programs

Literature investigating easement participants has also identified a positive association with plans for engaging in active forest management. Gutierrez-Castillo et al. (2022a) reported that about 63% of surveyed Louisiana easement grantors planned to carry out management activities to sustain their forests under easement within the next decade. Additionally, landowners who were members of a conservation organization and open to receiving lower thinning income, provided wildlife was protected, showed a positive correlation with a willingness to thin (Gutierrez-Castillo et al., 2022b). Similarly, Wolde et al. (2016)



The category ‘other’ programs include one block grant and one unknown program with an unknown scope; one conservation easement with no specified scope; and two programs related to the Minnesota Sustainable Forest Incentives Act.

Fig. 3. Number of studies examining financial incentive programs for SFM in the analysis by incentive type and administration.

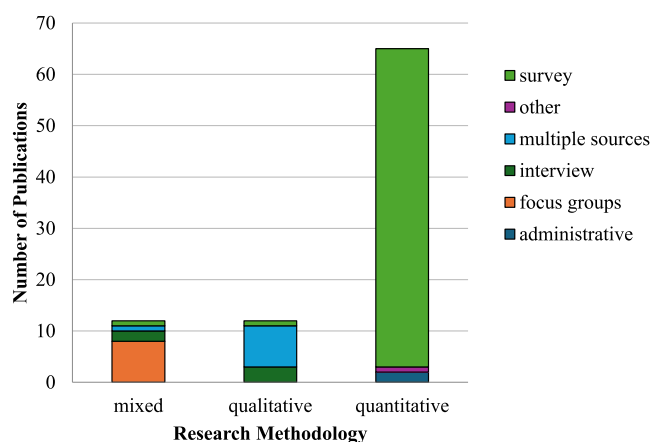


Fig. 4. Number of publications in the analysis by research methodology and sources of data.

identified a positive correlation between enrollment in financial and technical assistance programs and the development of forest management plans among landowners in Virginia and Texas. In the northern region of the US, however, while easement participation was closely associated with the adoption of forest management plans, the authors suggested that it did not stimulate active forest management behavior or decisions to undertake greater management practices (Song et al., 2014a).

Past experience with incentive programs

Literature also suggests that prior use of or experience with incentives may influence landowners' engagement in SFM activities and future incentive programs. For example, Kim and Langpap (2015) examined landowners' willingness to adopt forest management practices that enhance carbon sequestration and found a positive correlation between past usage of cost-share and the implementation of both fuel treatments and fertilization, but a negative correlation with the implementation of fuel treatments alone. Similarly, Charnley et al. (2020) reported that previous experience with the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) helped landowners take forest restoration actions. Of the surveyed landowners, about 52% established or maintained native plantings, and

about 72% implemented early successful forest management activities even after their contract ended with NRCS programs (Lutter et al., 2019b). In the southern states, unlike non-cost-share participants, past cost-share landowners were more willing to enroll in future cost-share programs (Hilsenroth et al., 2023). However, past participation in preferential property tax and stewardship incentive programs was found to be an insignificant predictor of landowners' willingness to consider forest certification and hypothetical incentives (Kłosowski et al., 2001; Mercker and Hodges, 2007; Ma et al., 2012). Likewise, Mutandwa et al. (2019) found that familiarity with the CRP did not significantly influence landowners' willingness to implement forest management activities in hypothetical CRP scenarios.

4.2. Question 2: What are landowners' attitudes toward incentives for SFM?

The majority of studies examining landowner perceptions of incentive programs (26 of 41 publications) were published over the last decade, and largely focused on a mix of incentive programs (19 of 41 studies), cost-share (7 of 41), and carbon offsets (5 of 41). Quantitative methods were the preferred approach for analyzing landowner perceptions (26 of 41 studies), using statistical and econometric analyses of telephone or mail survey data. Focus groups with landowners were the second most common source of information on landowner attitudes toward incentives.

Overall, studies find positive attitudes toward benefits of CRP participation (Thapa et al., 2024), and a positive association between landowner satisfaction with incentive programs administered by the NRCS, Farm Service Agency (FSA), and US Fish and Wildlife Service (USFWS) and contact with agency staff (Adhikari et al., 2022). Over 80% of landowners were satisfied or neutral with multiple incentive programs, although they were not asked if they actually participated in a program (Adhikari et al., 2022). This finding is similar to the overall satisfaction levels of participants of property tax programs (Butler et al., 2012). Dissatisfaction with property tax programs was related to program requirements, including contract length and renewal, withdrawal penalty (Fortney et al., 2011), eligibility requirements, and compensation (Butler et al., 2012). Similarly, landowners expressed dissatisfaction with forest carbon offset contract requirements (Miller et al., 2014) as well as the perceived uncertainty and risk associated with federal tax provisions (e.g., estate tax, federal income tax) (Greene et al., 2014) and forest carbon offsets (Thompson and Hansen, 2013; Miller et al., 2014).

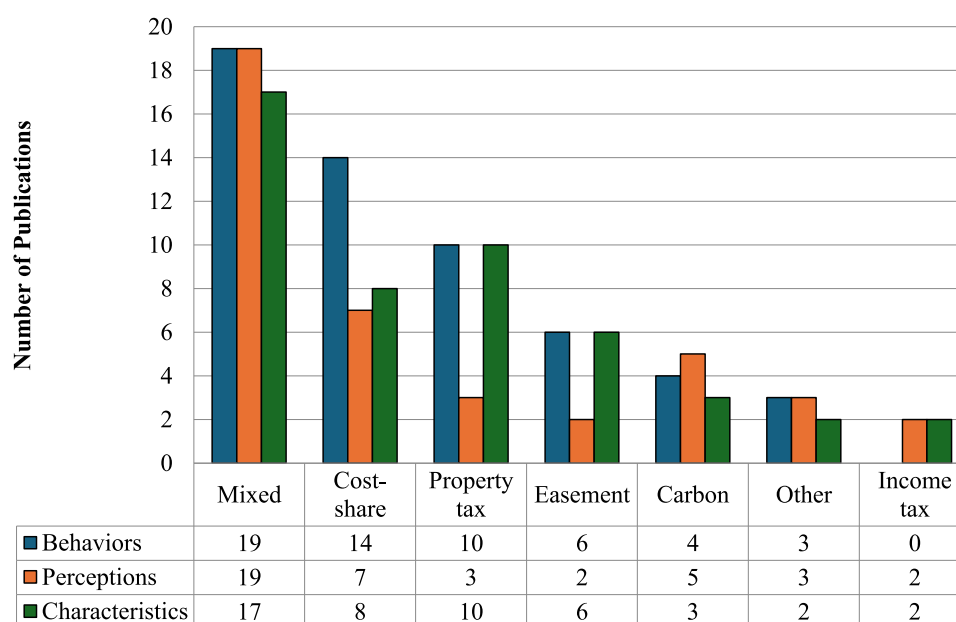


Fig. 5. Number of studies in the analysis that evaluated landowner behaviors, perceptions, and characteristics by incentive type.

Commonly perceived benefits of participation in incentive-based conservation programs included soil erosion control, livestock grazing, and income (Gan et al., 2005), as well as wildlife habitat (Lutter et al., 2019b). Soil erosion control, clean air, water, and recreation are among the ecosystem services landowners were most familiar with, relative to less familiar ones such as woody biomass, carbon sequestration, fee-based recreation, and biodiversity (Mutandwa et al., 2016). Tian et al. (2015) found that landowners interested in managing for carbon perceived government payments as useful incentives, while interest in managing forests for water and aesthetics was positively related to the attitude that property tax programs are useful incentives. Similarly, tax incentives and access to seedlings were preferred over cost-share programs, and technical assistance was valued more than direct payments in the context of agroforestry assistance (Strong and Jacobson, 2006). Perceptions of high costs borne by participants (Bell et al., 1994; English et al., 1997), program restrictions (Fortney et al., 2011; Butler et al., 2012), and limited available funding (Daniels et al., 2010) were negatively related to the likelihood of participation in incentive programs, including carbon offset programs (E.C. Kelly et al., 2017).

Focus group discussions reveal that landowners are critical of financial incentive programs for their inconsistent administration, slow enrollment procedures, lack of funding, waiting period for a forester to visit their property, and perception that some landowners may not implement cost-share activities (Kilgore et al., 2007). Among minority landowners in the US South, concerns about paperwork, lack of staff, and initial capital outlay were important considerations (Dwivedi et al., 2016). Researchers found that trust was key for minority landowners' perceptions of cost-share programs and that community-based pilot projects (e.g., technical assistance) were important for building trust among landowners and foresters to encourage SFM and retention of African American family land (Schelhas et al., 2017). Focus groups with African American landowners found that government assistance programs were perceived as inequitable, discriminatory, or unavailable to all landowners (Gordon et al., 2013).

4.3. Question 3: How are landowners that use or do not use financial incentives for SFM characterized?

The majority of the studies that evaluated landowner characteristics were published in the previous decade (27 of 48). The remainder of the studies were equally distributed among the 1990s, 2000s, and 2020s

with seven publications from each decade. One-third of the studies examined characteristics of users and non-users of incentive-based conservation programs with multiple types of incentives, whereas approximately two-thirds of the studies assessed individual types. Most studies utilized quantitative approaches (43 of 48) and survey data (37 of 48) to evaluate landowner characteristics. The one qualitative study used interview data, while the mixed-methods studies used data from focus groups, interviews, surveys, and multiple sources.

Compared to non-users, the literature on mixed incentives characterized landowners that use or likely use financial incentives as having higher levels of education and income (Kluender et al., 1999), owning greater acreages of land or forestland (Butler et al., 2021), and having objectives and reasons for ownership related to the socio-environmental values (Bell et al., 2019). Notably, incentive users in the mixed incentives literature were more likely to be female (Gan et al., 2005) and non-minority landowners (Butler et al., 2020). Generally, studies on mixed incentives have found that incentive users are active landowners and have demonstrated higher levels of engagement than non-participants through landowner associations and interaction with natural resource professionals (Ma and Kittredge, 2011; McGrath et al., 2021). However, characteristics such as landowner age (Gan et al., 2005; Ma and Kittredge, 2011) and tenure (Wolde et al., 2016), inherited land (Kluender et al., 1999; Wolde et al., 2016), and timber and investment ownership objectives (Bell et al., 2019; Butler et al., 2020; Wolde et al., 2016) had inconsistent effects on their consideration or usage of incentives for SFM.

In many cases, findings from studies on multiple incentive types aligned with the findings of studies that analyzed an individual incentive program or type. For instance, landowner education and income and land or forestland acreage were positively associated with participation in property tax programs (Dennis and Sendak, 1992; Meier et al., 2019) and cost-share programs (Butler et al., 2014; Ma et al., 2012). Socio-environmental values, objectives, or reasons for ownership were prevalent among conservation easement grantors (Farmer et al., 2011, 2015; Kittredge et al., 2013), property tax program enrollees (Fortney et al., 2011), carbon offset program participants (Sass et al., 2022), and cost-share program participants (Lutter et al., 2019a). Timber production and investment objectives were positively correlated with the use of income tax provisions (Green et al., 2004) and cost-share assistance (Nagubadi et al., 1996; Butler et al., 2014; Kilgore et al., 2015) but had a mixed relationship with property tax incentives (Nagubadi et al., 1996;

Williams et al., 2004; Meier et al., 2019). Further, a qualitative analysis of cost-share program participation highlighted the ability of active landowners to successfully navigate funding opportunities such as cost-share programs (Boag et al., 2018).

We noted a few discrepancies between the literature on mixed incentives and individual incentives. Sass et al. (2022) was the only study to assess the concern for climate change on participation in carbon offset programs, which was positively related to participation. Sun et al. (2009) and Williams et al. (2004) reported findings that do not align with the trends from other studies. Specifically, Sun et al. (2009) found that landowner income, total acreage owned, and membership in forestry organizations were negatively associated with application behavior for two cost-share programs and an income tax program, while Williams et al. (2004) concluded that forest ownership objectives such as investment purposes were negatively correlated with enrollment in Tennessee's property tax program. Similar to the literature on mixed incentives, there was no consensus in the literature on property tax programs regarding the relationship between landowner age and incentive use. For example, Nagubadi et al. (1996) reported that landowner age was positively correlated with property tax program participation in Indiana, whereas Fortney et al. (2011) found that age was negatively correlated with participation in West Virginia's property tax program.

5. Discussion

5.1. Question 4: Lessons from the literature on incentives for SFM

There are several lessons from this literature that could be of potential value to discussions about SFM and CSF programs. First, our review of the literature on financial incentive programs for SFM identified the prevalence of mixed-incentive research, which aligns with the current suite of incentive opportunities being utilized to support CSF (Inflation Reduction Act, 2022; Shen et al., 2023; NRCS, 2024b; USDA, 2024a, 2024b; USFS, 2024). More specifically, the literature consisted of a combination of tax and/or direct payment tools used by federal, state, nonprofit, and other organizations to encourage landowner behavior and practices that support the sustained provision of forest goods and services. Mixed-incentive research was also documented by Chizmar et al. (2021) as eight of the 21 studies in their analysis on state-level cost-share programs in the US South also featured tax programs. Interest in the relationship between incentive programs and landowner behavior, perceptions, and characteristics heightened in the early 2010s as witnessed in the increased rate of publications devoted to these topics (Fig. 1). This trend was also observed for the literature on family forest owners in the US, which peaked between 2011 and 2013 (Butler et al., 2023), and state cost-share programs for forest landowners in the US South (Chizmar et al., 2021).

Second, studies have found that participants of incentive programs for SFM are more likely than non-participants to actively manage their lands, to have harvested or plan to harvest, and to participate in more than one incentive program (Boag et al., 2018; Meier et al. 2019; McGrath et al., 2021; Sass et al. 2022). This is consistent with findings in the literature discussing financial tools (Jacobson et al., 2009a, 2009b) and federal assistance programs (Greene et al., 2010) as being moderately effective at promoting sustainable forestry practices (Floress et al., 2019). Similarly, Butler et al. (2023) reported evidence from their literature sample on the activeness of forest owners that use financial and technical assistance programs. Further, Floress et al. (2019) identified three of the six studies that evaluated the impact of incentive program experience on participation and found that participation in one incentive is positively correlated with participation in other incentive programs. Accordingly, prior use or experience with incentive programs might be expected to influence landowners' engagement with activities that support CSF in addition to SFM (Kim and Langpap, 2015; Lutter et al., 2019b; Charnley et al., 2020).

An important consideration, however, is the compatibility of incentive programs with current and emerging forest carbon offset programs, and the potential implications for additionality or the ability to participate in multiple programs sequentially or simultaneously. Estimates indicate that federal and state tax policies provide about \$8 billion per year in climate mitigation benefits due to forest management practices that sequester carbon (Daigneault et al., 2020). The limited literature on landowner perceptions of carbon offset programs indicates that key concerns for landowners willing to engage in these programs are costs, program restrictions (e.g., contract length, penalties), and perceived uncertainty (Thompson and Hansen, 2013; Miller et al., 2014; E.C. Kelly et al., 2017).

Third, the literature revealed generally positive landowner attitudes toward financial incentive programs (Adhikari et al., 2022; Thapa et al., 2024). Of importance for CSF, multiple studies have reported landowners recognize benefits from participation in incentive programs including benefits to forest ecosystems and environments (Gan et al., 2005; Tian et al., 2015; Mutandwa et al., 2016; Lutter et al., 2019b). However, landowners have also raised criticisms of these programs, including funding availability, program requirements (e.g., contracts, renewal, eligibility, paperwork), implementation challenges (e.g., slow enrollment, inconsistent administration, understaffing, waiting periods), and issues of trust (Kilgore et al., 2007; Fortney et al., 2011; Kelly et al., 2016; E.C. 2017; Schelhas et al., 2017). For minority landowners, in particular, trust in the organizations administering these programs and equitable access have been at the forefront (Gordon et al., 2013). Relationship-building between landowners and foresters or agency staff is another important but often overlooked component of landowners' perceptions of conservation programs (Kilgore et al., 2007). Similar to the studies featured in this analysis, fewer review studies have evaluated landowner attitudes and perceptions of incentive programs, but when attitudes and perceptions were included, they were found to influence program participation and implementation of management practices (Floress et al., 2019; Butler et al., 2023).

Fourth, landowners that have used incentives for SFM generally possessed larger landholdings, had higher levels of income and education (Kluender et al., 1999; Gan et al., 2005; Wolde et al., 2016; Butler et al., 2021), and owned lands for environmental values and objectives (Farmer et al., 2011; Fortney et al., 2011; Bell et al., 2019; Lutter et al., 2019a). Likewise, Floress et al. (2019) and Butler et al. (2023) identified evidence in the literature on the relationships between incentive program participation and attributes such as non-timber ownership objectives, parcel size, and landowner education. Furthermore, while non-white landowners were found to be less likely to participate in incentive programs (Butler et al., 2020), minority landowners that did participate tended to have owned larger acreages, completed more years of formal education, and earned higher levels of income from farm activities (Gan et al., 2005). These findings have implications for equity with respect to limited resource and minority landowners as both minority and non-minority landowners with smaller landholdings, less formal education, and lower levels of income were less likely to have participated in incentive programs. In order to address this disparity, initiatives for CSF have created specific programs targeted to traditionally underrepresented communities including small-acreage and minority landowners (National Indian Carbon Coalition, 2017; Chizmar and Parajuli, 2022; Inflation Reduction Act, 2022; USDA, 2022; USFS, 2024).

5.2. Areas for future research and limitations

This review highlights several information needs and areas for future work. First, future research on incentives for CSF should prioritize engagement with minority landowners and owners with smaller landholdings and lower income and education levels. A few studies in our sample included reasons for non-participation among minority landowners; however, these studies may not be representative of all minority

landowners in the US (Gan et al., 2005; Butler et al., 2020). For instance, Gan et al. (2005) found that significantly more minority landowners than non-minority landowners in Alabama did not participate in conservation incentive programs because they could not afford the cost-share, and significantly more non-minority landowners did not participate due to a lack of interest. As such, future research could engage with minority, limited-resource, and socially-disadvantaged landowners across the country to explore their potential interest in managing their forests for climate-related objectives with and without support from incentive programs and evaluate the impacts of broader economic factors on program interest and participation (e.g., the effect of interest rate fluctuations and timber price uncertainty). Incorporating a participatory action research framework (Cornish et al., 2023) will facilitate engagement with underrepresented and socially-disadvantaged landowners and enable collective identification of barriers and potential solutions that may be incorporated into current and future incentive programs for CSF.

Second, the effectiveness of incentive programs is contingent on successful implementation (Kilgore et al., 2018), but we currently know little about how administration of programs unfolds on the ground. Incentive programs may vary by (1) the parties involved, and when and how are they involved; (2) the inputs needed and outputs produced throughout the implementation process; (3) the communication channels for the various parties and their importance; and (4) the pathways to adapting implementation procedures (Kilgore et al., 2018; McGinley and Cabbage, 2020). Our findings from the literature suggest landowners perceive multiple attributes of incentive program implementation negatively including limited available funding, slow enrollment procedures, and long waiting periods for field foresters (Kilgore et al., 2007; Daniels et al., 2010; Dwivedi et al., 2016). Prior work highlights the need for improved administrative capacity and coordination in the administration and delivery of programs (Kilgore et al., 2007, 2008b). Yet, in the context of multiple and constantly evolving programs, there is limited understanding of which of these considerations are more or less important for landowners. Further, if lack of awareness is one of the primary reasons for non-participation (Fortney et al., 2011), what can program administrators do to increase learning among landowners with various backgrounds and levels of education? Future research could collect data from program administrators to characterize typical implementation procedures and highlight cases where programs were able to adapt to changing priorities and needs, which may be useful for decision-makers and CSF program administrators. Future research could also engage forest landowners to evaluate the importance of implementation considerations across various incentive opportunities.

While trends from the literature suggest landowners with prior incentive experience are more likely than those without experience to participate in other incentive programs, we currently have limited knowledge on program interactions (e.g., between existing incentive programs and emerging carbon payment schemes). As carbon offset programs become more widespread, consistent data and monitoring of landowner awareness and participation in these programs will be invaluable in informing program design and administration (Sass et al., 2022). To date, discussions on program compatibility have been program or program type specific (e.g., Diedrich and Clay, 2023). No research to our knowledge has assessed the compatibility and additive impacts from market-based opportunities across multiple incentive types and bundles of programs. We identified a lack of research that combines exploratory analysis techniques with quantitative assessment of actual participation and completion of forest management practices to address the lack of knowledge on program interactions and their potential impact on forest management outcomes.

Finally, it is important to note that studies on incentive programs for SFM are almost entirely based on surveys of forest landowners. This aligns with the finding by Butler et al. (2023). In many cases, certain landowners such as small-acreage owners were systematically excluded (e.g., Adhikari et al. (2022) excluded landowners with less than 10 acres

from their sampling frame). Most research in this area relies on landowners to recognize they are a forest landowner and be willing and able to respond to a survey. Another observation in the context of the dominant methodological approach in the literature is that findings are based on correlation analysis, limiting our ability to draw causal inferences. Studies incorporating experimental or quasi-experimental design to assess causation could be pursued to better understand the characteristics and behaviors of landowners influenced by incentive programs. Similarly, as incentive programs evolve and change, future research should investigate the effects of actual, rather than hypothetical, payments in ecosystem services and carbon offset programs to generate practical knowledge for practitioners and program administrators.

6. Conclusion

An evolving concept, SFM has become intertwined with recent initiatives promoting forestry practices that respond to and mitigate climate change. New government programs (USDA, 2024b; USFS, 2024) and market-based mechanisms (Shen et al., 2023) are emerging as incentive tools for subsidizing or supporting CSF. The questions driving this literature review were largely shaped by these trends and by the need to synthesize and inform current and emerging incentive programs for SFM and CSF. Specifically, this paper systematically reviewed forest landowner characteristics, behaviors, and perceptions of actual incentive programs analyzed in the US across 94 refereed articles published since 1992.

The lessons emerging from this synthesis highlight the prominence of mixed-incentive research taking off in the early 2010s, a finding consistent with prior research (Chizmar et al., 2021; Butler et al., 2023) and aligned with current federal programs and incentives for CSF (Inflation Reduction Act, 2022; Shen et al., 2023; NRCS, 2024b; USDA, 2024a, 2024b; USFS, 2024). We summarize key take home messages based on our review below. These messages can be shared with program administrators, policymakers, and the general public to inform discussions on programs for CSF.

- (1) There is substantial overlap between management practices that support SFM and CSF. Therefore, incentive programs that have traditionally supported SFM may also support CSF. In fact, some federal programs have already added provisions for supporting CSF.
- (2) Much of what we know about incentive programs for SFM and landowner behavior, perceptions, and characteristics is based on studies that were published relatively recently in the past 14 years.
- (3) The existing knowledge is built predominantly on studies using survey data that assess correlation and not causation. Research on causal relationships is needed to be able to assess cause-and-effect impacts of incentive programs on landowner behavior and perceptions.
- (4) Landowners that use incentive programs for SFM are more likely to have developed forest management plans, which may be associated with increased forest management activity. Of importance for conversations about incentive programs for CSF, increased occurrence of forest management plans may reflect program requirements, as many require an up-to-date management plan.
- (5) While many studies have found landowners with incentive program experience are more likely to be active forest managers, some studies did not find significant differences in forest landowner behavior between incentive program participants and non-participants.
- (6) Landowners are generally satisfied with incentive programs for SFM; however, landowners have expressed dissatisfaction with specific program attributes such as enrollment procedures,

eligibility requirements, costs and compensation, and incentive program uncertainty and risk. In the case of participation in programs for forest carbon management, uncertainty and risk were important considerations.

- (7) Landowners that use incentive programs for SFM are more likely to own forests for environmental values and objectives and perceive participation benefits to soil erosion control, income, and wildlife habitat, highlighting the importance of aligning incentive program benefits with the values and objectives of landowners.
- (8) Landowners that use financial incentives for SFM are more likely to have higher levels of education and income and own greater acreages of land or forestland. However, low levels of awareness and participation among small-acreage, low-income, lesser-educated, and minority landowners raises timely questions about the need for expanding programs to historically underserved landowners.
- (9) Landowners that have past experience with an incentive program generally are more likely to participate in other financial assistance programs, which could have implications for eligibility in programs that limit participation in multiple programs such as forest carbon offset programs.

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Stephanie Chizmar: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tamara Cushing:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Srijana Baral:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tatyana Ruseva:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Data availability

No data was used for the research described in the article.

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