# Has Forest Certification Reduced Forest Degradation in Sweden?

Laura Villalobos, Jessica Coria, Anna Nordén


Land Economics, Volume 94, Number 2, May 2018, pp. 220-238 (Article)

Published by University of Wisconsin Press

# Has Forest Certification Reduced Forest Degradation in Sweden?

**Laura Villalobos** *Postdoctoral researcher, Climate Change and Sustainable Development Sector, Inter-American Development Bank, Washington, D.C.*
**Jessica Coria** *Senior lecturer, Department of Economics, University of Gothenburg, Sweden*
**Anna Nordén**, *Project manager, Centre for Environment and Sustainability (GMV), Gothenburg, Sweden*

**ABSTRACT** *This paper estimates the effects of certification of nonindustrial private forest owners on forest degradation in Sweden—one of the countries with the largest total area of certified forests. We rely on official forest inventory data, information on certification status, and impact evaluation methods to identify the causal effect of certification on three key environmental outcomes. We find that certification has not halted forest degradation in that it has not improved any of the environmental outcomes. Moreover, for forest certification to have an effect, the standards should be tightened and the monitoring and enforcement of forest certification schemes strengthened.* (JEL Q23, Q28)

## 1. Introduction

Accelerated losses of old-growth forest and intensive timber production have serious consequences for biodiversity conservation due to the loss of habitats (Folke et al. 2004). Deforestation and forest degradation (understood as the decrease in forest quality with respect to the initial condition) also contribute to climate change, as they release between 10% and 15% of global human-induced greenhouse gas emissions (Van der Werf at al. 2009). Given a global deforestation rate of about 13 million ha per year, increasing efforts to maintain forests and their biodiversity through improved forest management is an important contemporary issue for several United Nations (UN) conventions. For example, the UN Convention on Biological Diversity sets a global target for restoration of at least 15% of degraded ecosystems by 2020, and the UN Framework Convention on Climate Change proposes to recover degraded forests as carbon sinks (see, e.g., Rametsteiner and Simula 2003; Thompson et al. 2013).

Forest certification is a voluntary, market-driven instrument whereby an independent third party (called a certifier or certification body) assesses the quality of forest management in relation to a set of predetermined environmental standards and gives written assurance that a product or process conforms to the requirements specified in the standards (Rametsteiner and Simula 2003). Producers who meet stringent environmental standards can then label their products in the marketplace, allowing them to potentially achieve greater market access and receive higher prices for their products. The general objective of forest certification is thus to provide information to consumers about the quality of forest management in areas from which traded wood products are sourced.

Forest certification has generated considerable attention in forestry as means to address deforestation and forest degradation by promoting improved environmental and social outcomes in forest management criteria (Blackman and Rivera 2011; Romero et al. 2013). As a consequence, the global area of certified forest has grown significantly. For instance, the global area of certified forest increased from 18 million ha in 2000 to some 438 million ha in 2014. About 90% of the total area certified in 2014 is in the temperate and boreal climatic domains, although there has also been growth, albeit at a slower pace, in the tropics and subtropics (FAO 2015).

The voluntary nature of forest certification implies, however, that environmental benefits from a certification scheme may be limited if only producers who are already meeting en-

*Land Economics* • August 2018 • 93 (3): 390–112
ISSN 0023-7639; E-ISSN 1543-8325

vironmental standards opt into certification. Hence, to properly assess the effectiveness of forest certification, we need to account for forest owners who would manage their forestlands in compliance with certification program criteria even without the incentive afforded by program participation. Unfortunately, due to the lack of suitable information, the evidence regarding the impact of forest certification on environmental outcomes using rigorous impact evaluation methods is still very limited and shows that the effects might be context dependent, as the literature finds mixed results. For example, studies indicate that forest certification has reduced deforestation in timber concessions in Indonesia (Miteva, Loucks, and Pattanayak et al. 2015) and Chile (Heilmayr and Lambin 2016). In contrast, no evidence of certification reducing deforestation has been found under communal land management in Mexico (Blackman, Goff, and Rivera Planter 2015), or under concessions in Peru and Cameroon (Panlasigui et al. 2015).

This paper investigates the effects of the two main certification schemes (the Forest Stewardship Council [FSC], and the Programme for the Endorsement of Forest Certification [PEFC]) on forest degradation in Sweden—the country with the largest total area of certified forest in Western Europe (UNECE/FAO 2012). A key feature of our research is that unlike previous studies, which use remote-sensing data sources, we use detailed forest inventory data of nonindustrial private forest owners at the plot level both before and after felling. This ground information is able to capture subtle changes in the amount and composition of the forest in small areas with higher precision than remote data sources, thus providing more precise estimates of the effects of forest certification (Vincent 2016). Furthermore, in contrast to previous studies analyzing the effects of forest certification on the rates of deforestation, we focus on the effects on avoided degradation.

## 2. Study Context

Sweden's boreal forest has experienced radical human-induced changes since the beginning of industrialization. Ecological structures such as large, dead, and deciduous trees have been removed from the forest, and natural processes have been suppressed, leading to ecosystem degradation. Current evidence indicates the need for restoration, because the intensification of forest management to enhance wood production has reduced forest biodiversity and resilience (Gauthier et al. 2015; Nordlind and Östlund 2003).

Indeed, forestry is a key economic activity that represents around 11% of Swedish total employment and exports (RSAAF2015). Fifty-seven percent of the Swedish land area is productive forest, where Norway spruce and Scots pine are the dominant species with 78% of the standing volume, and the harvest's final use is mainly pulp, paper, and sawn timber production. Most of these products are exported, giving Sweden a top place within the world's leading exporting countries in the forest industry (RSAAF2015). Mechanized clear-cutting is the dominant management system, resulting in an evenly aged forest, and it is typically subcontracted. Harvest is followed by compulsory reforestation, which is mainly done by manual planting (also subcontracted) or by natural regeneration (RSAAF2015).

There are several stakeholders in the sector, including around 330,000 private owners who are the base of the system, as they own half of the productive forest area and 60% of the total annual yield in Sweden (Swedish Forest Agency 2014). The other major category is private sector companies, with 25% of the productive forest (Swedish Forest Agency 2014). It is common for individual owners to supply industrial enterprises and to belong to a forest association, where they obtain advisory services and representation in forest policy (RSAAF 2015).

The timber market in Sweden is less regulated than in most other countries, and forest management is based on a "freedom with responsibility" and "soft governance" policy that includes wide-ranging discretion for forest owners to manage their forests (RSAAF 2015). Still, conservation targets are a priority policy issue. The Swedish Forestry Act states that environmentally important areas must not be damaged or destroyed during felling.

In particular, sensitive habitats, unusual trees and shrubs, and buffer zones have to be kept intact. Sensitive habitats are areas with high natural values deviating from the evenly aged production forest. Unusual trees and shrubs are those that have had time to develop some form of natural value, for example, older, slow-growing, large, or rare trees. Buffer zones and riparian zones are areas important for the conservation of species diversity in the forest floor, wetlands, lakes, and streams. The Swedish Forest Agency provides forest owners with detailed information about the definition of these categories, including, for example, illustrative pictures to facilitate their identification on the ground (Swedish Forest Agency 2010).

Two certification schemes operate in Sweden. FSC certification was launched in 1998 when a working group comprising different forest stakeholders, including the NGO Swedish Society for Nature Conservation, introduced a national standard based on the international FSC guidelines. In contrast, the PEFC started in 2000, driven by private forest owner associations (see Johansson and Lidestav 2011). The FSC initially targeted large-scale forest companies, while the PEFC focused on small-scale private forest owners. However, at present, both standards certify any scale of operations from a minimum of 0.5 ha and are very similar in terms of requirements.

It is estimated that 50% of all productive forestland is certified under the FSC and 48% under the PEFC (RSAAF 2015). It is possible to hold both certifications simultaneously. Important for our research is that all major large-scale companies are FSC certified, making it difficult to identify the impact of certification on these contracts due to the lack of a control group. Therefore, our analysis focuses on nonindustrial private forest owners, of whose land only around 17% is certified (Johansson and Lidstav 2011).

Adherence to forest certification is voluntary, and the only eligibility requirement is to have productive forest with management purposes. However, the forest owners face transaction costs associated with the certification process. Information collected through a phone survey suggests that costs range between a one-time payment of around €1,900 and an annual fee of €210.[1] Because the scale of operations is typically small for nonindustrial private forest owners, they opt for group certificates to reduce transaction costs.[2] It is through this scheme that timber suppliers for companies, associations, and larger private owners are certified. In all cases, the certification is valid for 5 years, after which renewal is possible upon request.

Whereas FSC and PEFC Sweden set the standards, in practice seven certifiers manage the certification. These certifiers are authorized by accreditation organizations, namely, Accreditation Services International (ASI) for the FSC and Swedish Board for Accreditation and Conformity Assessment (Swedac) for the PEFC. The certifiers are responsible for monitoring compliance with the standard and are themselves inspected by the accreditation organizations. For the group certificates, the lead contract holders also monitor their respective members through annual spot checks.

The accreditation organizations, too, make random spot checks of certified forest every year to verify that the certification standards are followed. In case of violation, a corrective action request (CAR) is issued, allowing for up to 12 months to remedy a small deviation and up to 3 months for a large one. After this, if the CAR is not attended to, the forest owner loses the certificate. Uncorrected or serious violations of a single member within a group certificate leads to its exclusion from the certificate. A report by the World Wildlife Fund (Hirschberger 2005) analyzed the public reports of the CARs over the period 1997–2005

[1] Exchange rate for euros to Swedish krona (SEK) is 9.15. These estimates are based on 65 valid answers, 50 of which reported having made a one-time payment of SEK 17,421 on average, and the other 15 reported an annual fee of SEK 1,925 on average. These figures must, however, be interpreted with caution since there is great variation in the responses (e.g., for group certificates, the direct costs are determined by each group certificate organization separately, and the costs consist of an affiliation fee and a yearly fee). Depending on the size of the forest, the affiliation fee ranges from SEK 550 to SEK 2,500 and the yearly fee from SEK 300 to SEK 3,000 (Prosilva Skogscertifiering AB 2015).

[2] Small forest owners (with forest properties less than 1,000 ha of productive forest land) can be part of a group certificate. The organization in charge of the group certificate is responsible for a large part of the administrative work, which makes it easier for small forest owners to participate. At the moment there are 14 such organizations.

and concluded that most CARs in Sweden concerned environmental issues, and most of the major transgressions concerned the failure to leave biodiversity trees and dead wood, as well as the lack of conservation of habitats and biotopes.

Timber prices vary greatly depending on factors such as tree species, timber quality, infrastructure, and geographical location. Although precise statistics are hard to obtain, explorative figures suggest that certified timber has a price premium of up to 5%, according to figures reported by the Swedish Forest Agency (2014) and publicly available information on the websites of some forest owners associations and industrial companies.[3] Forest owners may also view certification as a way to establish a competitive advantage in the forest product marketplace. Certification may create opportunities to access new markets that favor certified forest products. For example, green building and publishing companies give preference to certified wood products, and these markets are growing in popularity (European Commission 2011). Indeed, demand for certification is also driven by legislation like the Lacey Act (United States) and FLEGT (Europe), which stipulate that only certified timber can be traded on these markets.

## 3. Methods

We investigate three key environmental outcomes on which certifications are expected to have an impact. First, we look at the effect of certification on the preservation of environmentally important areas during felling, a criterion that is at the core of the environmental principles of the certification standards (FSC 2009, 2010, 2013). Second, we look at the number of trees and high stumps remaining in the plots 5 to 7 years after felling. High stumps have many important functions, as food resource, habitat, or shelter (Söderström 2009). Because of the ecological value of these remainders, the certification standard encourages forest owners to leave both living wood and high stumps after clearing. Finally, we look at the certifications' requirement to set aside at least 5% of the total forestland for conservation purposes. Set-aside areas are considered a cost-efficient way to conserve biodiversity in managed and fragmented forest landscapes because they provide increased structural variation and availability of habitats and substrates and improve species' dispersal abilities and long-term survival in the forest landscape (Timonen et al. 2011; Wikberg et al. 2009).

### Data

*Environmentally Important Areas*

In Sweden, all forest owners must submit a notification form to the Swedish Forest Agency before felling. On average, the agency receives 40,000 notifications from nonindustrial private forest owners per year. From this pool, the agency selects a random sample of plots for ground inspection.[4] During this unannounced field visit, inspectors conduct a forest inventory of the plot. One growing season (around one year) after the felling, the agency returns to the same plot and conducts another inventory to assess the new conditions. The Swedish Forest Agency condenses this information in a dataset called "consideration monitoring" (formerly called Polytax 0/1, where 0 stands

[3] For instance, if we consider that the average price of Norway spruce sawlogs corresponded to SEK 466/m$^3$, the price premium corresponds to SEK 23.3/m$^3$ (Swedish Forest Agency 2014). Also, the forest owner association Södra Skogsägarna and the large forest owner Holmen explicitly state the price premium to FSC-certified wood on their websites. Södra Skogsägarna pays an extra SEK 10/m$^3$ for wood that is certified by either FSC or PEFC, and SEK 20/m$^3$ if certified by both. Holmen pays SEK 10/m$^3$ for FSC- or PEFC-certified wood and SEK 20/m$^3$ if certified by both in Östergötland and Småland. In other areas (e.g., Södermanland and Västmanland) Holmen pays SEK 5/m$^3$. Translated into percentages, the price premium of FSC-certified (or PEFC-certified) wood for Södra Skogsägarna ranges between 1.64% and 2.08%. The price premium of wood certified according to both FSC and PEFC ranges between 3.17% and 4.17%. For Holmen, the respective ranges are between 0.90% and 1.98%, and 3.00% and 3.97%.

[4] Over the period 1999–2011, the rate of inspection has ranged from a minimum of 0.4% of all applications in 1999 to a maximum of 1.07% in 2009 (and an average of 0.6%). The Swedish Forest Agency uses a stratified sample based on geographic location to ensure representation of every county, and within strata they choose the sample randomly. This process results in a slight overrepresentation of forest in southern Sweden.

for the data collected before the felling and 1 for the data collected one year after).[5]

The main purpose of the dataset is to assess the environmental considerations applied during the felling. It includes precise measures of the environmentally important areas defined by the Swedish Forestry Act and required by the certification standards. We define the total environmentally important area as the sum of the areas with sensitive habitats, buffer zones, and unusual trees and shrubs.[6] As these areas are measured by the inventory both before and after clearing, we can observe the magnitude of the reduction in the total environmentally important area for each plot.

From this measure, we define our outcome variables. First, we classify the plots depending on their compliance status. A plot is under compliance if all its environmentally important area was maintained during the felling. In contrast, a plot is not compliant if there is a reduction in the environmentally important area. Hence, the noncompliance rate is defined as a categorical variable taking the value 1 for any positive reduction in the relevant area, and 0 if there is no change. Second, we look at the magnitude of the damage in hectares, measured as the difference in total environmentally important area before and after clearing.[7] Finally, we consider the magnitude of the damage in relative terms, namely, as a share of the total environmentally important area before clearing. This is important because there could be substantial variations in the magnitude of the environmentally important areas across plots. Our hypothesis is that if forest certification promotes a more sustainable management of the forest, both the compliance rate and the magnitude (in absolute and relative terms) of environmentally important area left after clearing should be larger (and positive) for certified forest owners.

### *Trees and High Stumps Left*

The second dataset utilized is called "regeneration monitoring" (formerly named Polytax 5/7). It is based on a different sample of randomly chosen plots than the consideration monitoring dataset, and it is also collected by the Swedish Forest Agency, with the aim of assessing regeneration conditions five years after the felling (in the south of Sweden) and seven years after the felling (in the north of Sweden). The added value of this dataset is that it includes measures of two additional outcomes that are relevant in terms of ecological value, which allows for a more comprehensive analysis of the certification effects. In particular, we consider the number of trees and high stumps left (per cleared hectare) and the corresponding probabilities of noncompliance. As the certification requires leaving at least 10 trees and 3 high stumps, we define noncomplying plots as those with less than these numbers of trees per cleared hectare.

### *Phone Survey*

For the purpose of our analysis, a key variable missing in these two datasets is whether the plot has adhered to a certification scheme. This missing information is what has prevented them from being used in previous analyses of the impacts of the certification program in Sweden. To collect such information, we conducted a phone survey[8] in which forest owners were asked about their certification status, date and type of certification, and participation in forest associations (see Appendix Figure B1 for the survey questionnaire). In addition, we asked forest owners for their main motivation for being or not being certified, in-

[5] This and the other Swedish Forest Agency datasets used in our analyses can be obtained directly from the agency by contacting Andreas Eriksson, Forestry Manager, Swedish Forest Agency, Policy and Analysis Unit, Gothenburg, Sweden.

[6] We convert the number of unusual trees and shrubs into area multiplying by a factor of 0.0025, as suggested by the SFA.

[7] Importantly, the distribution of the area cleared defined in hectares is positively skewed. The bulk of the data are concentrated on the left-hand side of the probability distribution, with 35% of the observations concentrated at the zero value and another 60% between zero and 1 ha. As a robustness test, we use the inverse hyperbolic sine transformation of the area cleared, defined as $\log[y+(y^2+1)^{1/2}]$, where y is the area cleared in hectares. Unlike the log transformation, this function avoids eliminating data as it is defined at zero values.

[8] The survey was conducted by SIFO, between April 22, 2014 and May 9, 2014.

formation we present in Appendix Table B1. The fact that 45% of the respondents declared that they obtained the certification because it is economically viable is consistent with the benefits expected from the certification, namely, price premium and access to markets.

*Set-Aside Areas*

The last database utilized in our study corresponds to the set-aside area survey conducted by the Swedish Forest Agency. In the survey, a random sample of small and medium-size forest owners was selected for a phone survey asking specifically about forestland voluntarily set aside for conservation purposes. Even though these data have been collected several times since 1996, we focus on the survey conducted during 2009–2010 because it is the only survey that has included the certification status of the forest owner.

As mentioned above, the units of observation are small and medium-size forest owners (including social and local associations, as for instance, municipalities, foundations, religious communities, and economic associations). The survey includes information on the municipality in which the land is located, whether there are voluntary set-aside areas, the size of voluntary set-aside areas, whether the forest owner is certified, and if so, for how long. We complemented this dataset with information from the Swedish Forest Agency on the total area that the forest owner owns within a municipality. With this information, we define the share of total land that is set aside voluntarily for conservation purposes. We then compare whether the average shares of set-aside areas differ between certified and noncertified forest owners.

Unfortunately, the data in this survey do not include sufficient information on other characteristics of the land or the forest owners for us to use as control variables. Fortunately, location allows us to control for some of the geographical variation, and size of the plot allows us to control for variations in the opportunity cost of setting aside areas for conservation purposes, as opportunity cost might vary with scale. Nonetheless, our results should be interpreted with caution, since the observed differences in the share of set-aside area could be explained by other characteristics omitted from this analysis due to lack of information.

## Descriptive Statistics

*Environmentally Important Areas*

We base our analysis of the effect on the environmentally important areas on the plots included in the consideration monitoring dataset during the period 1999–2011 for nonindustrial private forest owners under the category of regeneration felling. The total number of plots inspected during this period and under this category was 3,037. In Table 1, we describe this sample, after excluding 1% of the observations due to missing or invalid information on key variables. The average plot size is 6.7 ha, of which 10.5% is environmentally sensitive area. This small proportion is not surprising, as most of these areas are mainly productive forests. Furthermore, we observe that on average the area of environmentally important areas decreases by roughly 30% after clearing.

Interestingly, the share of the sample that does not comply with the requirement of protecting all environmentally important area is 64%,[9] and the average damage is 0.2 ha (29%) of the initial environmentally important area. This is not a negligible amount if we consider that the Swedish Forest Agency receives around 40,000 notifications of felling every year, which results in over 8,000 ha of environmentally important areas being cleared annually. If we consider the noncompliers only, we find that this group clears on average 42% of the initial environmentally important area. Table 1 also presents some basic demographic characteristics of the forest owners of the plots included in the sample. The average plot is legally under the property of a 60-year-old male who lives in or close by the plot and makes counseled decisions regarding the forest management.

[9] We define the total environmentally important area as the sum of the areas of sensitive habitats, buffer zones, and unusual trees and shrubs, as required by the certification standards. This definition is slightly different than what the Swedish Forest Agency uses to define noncompliance, mainly because we do not consider the intrusion restriction.

**Table 1**

Environmentally Important Areas Analysis: Descriptive Statistics for the Consideration Monitoring Dataset

| | All Sample $N = 3{,}005$ | | | | Final Sample $N = 763$ | | Certified $N = 247$ | Noncertified $N = 516$ | FSC[a] $N = 53$ | PEFC[b] $N = 75$ | Both $N = 82$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Min. | Max. | Mean | Difference (All – Final) | Mean | Mean | Mean | Mean | Mean |
| *Plot Characteristics* | | | | | | | | | | | |
| Area requested for felling (ha) | 6.705 | 8.231 | 0.500 | 120.000 | 6.480 | 0.302 | 5.752 | 6.828 | 7.766 | 5.672 | 5.037 |
| Environmentally important area | | | | | | | | | | | |
| Before clearing (ha) | 0.706 | 1.695 | 0.000 | 39.500 | 0.673 | 0.045 | 0.502 | 0.755 | 0.788 | 0.447 | 0.415 |
| After clearing (ha) | 0.497 | 1.393 | 0.000 | 39.500 | 0.474 | 0.031 | 0.341 | 0.537 | 0.422 | 0.305 | 0.319 |
| Noncompliance rate (0/1) | 0.641 | 0.480 | 0.000 | 1.000 | 0.649 | –0.010 | 0.623 | 0.661 | 0.755 | 0.560 | 0.598 |
| Environmental damage (ha) | 0.209 | 0.849 | 0.000 | 21.915 | 0.199 | 0.014 | 0.161 | 0.217 | 0.366 | 0.142 | 0.096 |
| Damage/area before clearing | 0.288 | 0.349 | 0.000 | 1.000 | 0.273 | 0.019 | 0.266 | 0.277 | 0.342 | 0.301 | 0.209 |
| Noncompliers only | | | | | | | | | | | |
| Environmental damage (ha) | 0.326 | 1.042 | 0.002 | 21.915 | 0.307 | 0.026 | 0.258 | 0.329 | 0.485 | 0.254 | 0.161 |
| Damage/area before clearing | 0.420 | 0.350 | 0.000 | 1.000 | 0.395 | 0.034* | 0.397 | 0.394 | 0.454 | 0.473 | 0.320 |
| *Forest Owner Characteristics* | | | | | | | | | | | |
| Female (0/1) | 0.242 | 0.428 | 0.000 | 1.000 | 0.166 | 0.101*** | 0.121 | 0.188 | 0.132 | 0.107 | 0.134 |
| Single decision maker (0/1) | 0.273 | 0.446 | 0.000 | 1.000 | 0.642 | –0.495*** | 0.587 | 0.669 | 0.585 | 0.627 | 0.646 |
| Age (years) | 59.337 | 13.003 | 23.000 | 94.000 | 60.308 | –1.302*** | 59.364 | 60.760 | 58.698 | 58.680 | 60.512 |
| Owner lives near forest plot (0/1) | 0.780 | 0.415 | 0.000 | 1.000 | 0.811 | –0.042** | 0.838 | 0.798 | 0.925 | 0.827 | 0.805 |

*Note:* "All sample" refers to the complete sample of plots under the category of nonindustrial private forest owners that are randomly selected by the Swedish Forest Agency for forest inventory and monitoring both before and after clearing during the period 1999–2011. We excluded 1% of the observations due to missing or invalid information in any of the variables presented in this table. "Final sample" comprises the plots for which the certification status could be verified. FSC, Forest Stewardship Council; PEFC, Programme for the Endorsement of Forest Certification.

[a] Includes plots certified with the FSC before clearing but excludes plots that in addition obtained PEFC certification after clearing (20 observations).

[b] Includes plots certified with the PEFC before clearing but excludes plots that in addition obtained FSC certification after clearing (17 observations).

$p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

From the consideration monitoring dataset, we successfully collected information for 1,412 plots (response rate 45%) through the phone survey.[10] From this sample we obtained 763 observations with complete information regarding the certification status and other key variables.[11] In Table 1 we compare this subsample with the full consideration monitoring dataset in order to assess whether it is representative of the entire sample of inspected plots. We include both the mean value for each characteristic and a statistical test for the difference in means with respect to the full sample. We observe that the average plot is identical in both samples in terms of size, environmentally important areas, and noncompliance rate and magnitudes. The plots are also balanced in terms of geographic location, as we find no systematic differences in the proportion of observations per county between the subsample and the full consideration monitoring dataset. It is reassuring that the plots in our sample mimic the population of inspected plots at least in the characteristics relevant for our analysis.

However, as might be expected from a survey conducted by phone, we do find differences in the demographics of the forest owners. For example, in our survey, the respondents are on average 1.3 years older compared to the full sample, and we obtained a smaller proportion of female forest owners. To the extent that certification status depends on demographics, these differences could introduce some bias into our sample. For example, if female forest owners are more likely to be certified than males, our sample could misrepresent the share of certified forest owners in the full sample. We correct for selection bias by including the variables that control for sample selection. In addition, in Section 4 we present a robustness test where we show that the results are robust to a Heckman (1979) sample selection model.

Using the information on the type and date of certification, we classify the observations that were certified at the moment of clearing into four treatment groups and one control group. Treatment 1 is the most general and includes all plots with at least one certification at the moment of clearing, regardless of type and whether they add the other certification after felling (247 observations). We also look at the effect of each standard independently by defining Treatments 2 and 3. Treatment 2 includes plots that were FSC certified at the moment of clearing that were not certified according to PEFC after felling (53 observations). Similarly, Treatment 3 includes plots that were PEFC certified at the moment of clearing, with no FSC certification after felling (75 observations). Finally, Treatment 4 contains plots holding both certifications at the moment of clearing (82 observations). The control group comprises plots not certified during the entire period of analysis (516 observations). In Table 1 we can see that the rate and magnitude of noncompliance is lower for certified plots. The rest of the statistical analysis is devoted to analyzing whether this difference is statistically different from zero and whether it can be attributed to the certification.

We describe further our final sample in Appendix Table A1, where we present the descriptive statistics of the set of control variables that will be useful in estimating the causal effect of certification. These are characteristics that could explain the quality of forest management and be correlated with the certification status. In particular, we account for geographic characteristics of the plots, including the plot area, soil quality, density of roads in the municipality, and county. In a fairly homogeneous landscape, as in the Swedish case, these variables are expected to capture most of the variation in the productivity of the plots and their connectedness to markets.

In addition, we include characteristics of the forest owners that could determine their certification status, including participation in forest associations, and demographics such as education level, gender, age, experience, and

[10] It was not possible to contact the other 28% of the listed forest owners because of several other reasons, including unidentified, wrong, blocked, or nonexistent phone numbers.

[11] In particular, we dropped (1) observations lacking information on certification status or year of certification (183 observations), (2) outliers and observations with missing values on key variables (58 observations), (3) observations with unknown certifier label (226 observations), and (4) plots cleared before the owner obtained the certification (182 observations). However, results hold if we consider plots certified at any time by any label (714 observations), a sample that is comparable with how the regeneration monitoring dataset was constructed.

**Table 2**

Trees and High Stumps Left Analysis: Descriptive Statistics for the Regeneration Monitoring Dataset

| | All Sample $N = 2,593$ | | | | Final Sample $N = 1,065$ | | Certified $N = 619$ | Noncertified $N = 446$ |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Min. | Max. | Mean | Difference (All – Final) | Mean | Mean |
| *Plot Characteristics* | | | | | | | | |
| Area requested for felling (ha) | 6.734 | 8.105 | 0.500 | 94.200 | 6.786 | –0.088 | 6.364 | 7.371 |
| Number of trees left per hectare of cleared forest | 8.813 | 12.182 | 0.000 | 180.534 | 0.697 | 0.142 | 9.356 | 7.859 |
| Number of high stumps per hectare of cleared forest | 1.427 | 2.296 | 0.000 | 19.111 | 0.812 | –0.109 | 1.662 | 1.255 |
| Noncompliance rate (trees left) | 0.708 | 0.455 | 0.000 | 1.000 | 8.729 | 0.019 | 0.661 | 0.747 |
| Noncompliance rate (high stumps) | 0.822 | 0.382 | 0.000 | 1.000 | 1.492 | 0.017 | 0.790 | 0.843 |
| *Noncompliers Only* | | | | | | | | |
| Number of trees left per hectare of cleared forest | 3.350 | 2.965 | 0.000 | 9.976 | 3.374 | –0.040 | 3.256 | 3.519 |
| Number of high stumps per hectare of cleared forest | 0.553 | 0.881 | 0.000 | 2.989 | 0.557 | –0.007 | 0.595 | 0.508 |
| *Forest Owner Characteristics* | | | | | | | | |
| Female (dummy) | 0.240 | 0.427 | 0.000 | 1.000 | 0.176 | 0.110*** | 0.168 | 0.186 |
| Single decision maker (dummy) | 0.290 | 0.454 | 0.000 | 1.000 | 0.638 | –0.591*** | 0.601 | 0.691 |
| Age (years) | 59.957 | 12.971 | 10.000 | 99.000 | 60.023 | –0.112 | 60.047 | 59.989 |
| Owner lives near forest plot (0/1) | 0.802 | 0.399 | 0.000 | 1.000 | 0.823 | –0.037** | 0.832 | 0.812 |

*Note:* "All sample" refers to the complete sample of plots under the category of nonindustrial private forest owners that are randomly selected by the Swedish Forest Agency for forest inventory and monitoring both before and after clearing during the period 1999–2011. We excluded 1% of the observations due to missing or invalid information in any of the variables presented in this table.

$p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

how involved the forest owners are in forest management (measured by whether they live close to the plot and by whether they make decisions on their own as opposed to with peers). These variables are expected to capture differences in the level of environmental awareness and access to information. Note that participation in forest associations reduces the transaction cost and up-front payment to become certified, and hence it is expected to play an important role in the probability that a forest owner becomes certified.

Slightly over one-third of the forest owners in our sample completed high school, and most of them have at least six years of experience managing the forest. In terms of participation in forest associations, 40% of the sample does not belong to any association, whereas 23% belongs to the southern forest owners' association and 16% to the central forest owners' association. Most of the plots have medium soil quality, which is a measure of the forest growth rate per unit of time.

### *Trees and High Stumps Left*

Our analysis of the trees and high stumps left is based on the 2,616 observations in the regeneration monitoring dataset for the period 1992–2010. In Table 2, we describe this sample, after excluding 1% of the observations due to missing or invalid information on key variables. The average plot size is 6.7 ha, the same size as the average plot in the consideration monitoring dataset. On average, forest owners leave 8.8 trees and 1.4 high stumps per hectare of cleared forest, which is less than the numbers required by the certification. Also, the rate of noncompliance with the expected density is 71% for trees and 82% for high stumps. These rates of noncompliance are by all means high but consistent with reports, indicating that failure to leave biodiversity trees and dead wood is the most common transgression of certification standards (see Hirschberger 2005). Noncompliers leave only 3.3 trees and 0.5 high stumps per hectare, on average. Notably, the profile of the forest owner is consistent with the one for the consideration monitoring dataset.

Through the phone survey, we successfully collected information for 1,231 plots (response rate 47%). After removing observations lacking information regarding certification status or felling year, and outliers and missing values, we obtain a final sample of 1,065 observations. In Table 2, we compare our final sample with the characteristics of the full regeneration monitoring dataset. Similarly to the consideration monitoring dataset analysis, we find that our final sample resembles the population of inspected plots in terms of size, and noncompliance rate and magnitude. However, once again we find differences in the demographics of the forest owners, which is not surprising as the sampling procedures for both databases are similar. Interestingly, the direction of the differences is analogous to those in the consideration monitoring dataset, as for example, there are fewer females and older owners in our sample.

As with the previous analysis, we classify the observations according to their certification status at the time of clearing. Due to a small sample size in each of the categories previously defined, in this case we define only one treatment and one control group.[12] The treated group corresponds to all plots ever certified (619 plots). This slightly modifies the interpretation of the results as we cannot control for the type of certification. In the control group, we include the 446 plots that were not certified during the period of analysis.

### *Set-Aside Areas*

Altogether, the set-aside dataset includes 327 small and medium-size private forest owners who participated in the survey. We exclude forest owners with missing information or no set-aside areas, for a final sample size of 283 (86%) observations with valid information on the variables of interest. Of those, 95 observations do not hold a forest certification, 57 are certified by the FSC, and 131 are certified by the PEFC. Table 3 presents descriptive statistics for the relevant variables. We observe that on average, forest owners set aside 8.8% of their forested area for conservation purposes, which is higher than the 5% required by the standard. Moreover, approximately 60% of our sample set aside more than 5% (on average 13%), while 40% set aside less than required by the standard (on average 3%). We also observe that certified owners have smaller forest area but set aside a higher proportion compared to noncertified owners. However, this difference in not statistically different from zero (see Section 4).

## Empirical Model

Our treatment assignment is not random, since the certification program is voluntary. In this case, the challenge when trying to identify the causal effect is that if certified plots are systematically different from the uncertified group, we cannot attribute all the potential differences in the outcomes to the certification status. Rather, these differences could be explained by other factors, commonly referred to as confounders.

Appendix Tables A2 and A3 present the normalized differences in covariates between the control and treated groups for the consideration monitoring and regeneration monitoring datasets, respectively. For each characteristic, the normalized difference is defined as the difference in averages by treatment status, scaled by the square root of the sum of the variances. The normalized differences provide a scale- and sample size–free way of assessing overlap, and compared to the *t*-statistic, this metric is more useful for assessing the magnitude of the difference between the groups (Imbens 2015). As a rule of thumb, values above 0.25 indicate that the difference between the groups is substantial, and hence, linear regression methods tend to be sensitive to the specification (Imbens and Rubin 2007). We also report the t-statistic for the difference in means as a reference.

[12] For the regeneration monitoring dataset, only for 51 observations could we determine both the certification label and whether the plot was under certification by the time it was cleared.

**Table 3**
Descriptive Statistics Set-Aside Areas

| Variable | Observations | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| *All Sample* | | | | | |
| Set-aside area (ha) | 283 | 148.456 | 879.565 | 0.400 | 12,588.000 |
| Productive forest (ha) | 283 | 1,117.629 | 3,432.936 | 7.000 | 38,728.000 |
| Set-aside area (%) | 283 | 0.088 | 0.121 | 0.000 | 0.987 |
| Observations with 5% or less of set-aside area | 113 | 0.028 | 0.015 | 0.000 | 0.050 |
| Observations with more than 5% of | 170 | 0.128 | 0.142 | 0.050 | 0.987 |
| set-aside area | 170 | 0.128 | 0.142 | 0.050 | 0.987 |
| *Any Certification* | | | | | |
| Set-aside area (ha) | 188 | 118.198 | 510.169 | 0.500 | 5,343.000 |
| Productive forest (ha) | 188 | 1,036.766 | 2,230.048 | 7.000 | 16,145.000 |
| Set-aside area (%) | 188 | 0.096 | 0.123 | 0.003 | 0.987 |
| *Noncertified* | | | | | |
| Set-aside area (ha) | 95 | 208.334 | 1,340.774 | 0.400 | 12,588.000 |
| Productive forest (ha) | 95 | 1,277.653 | 5,042.108 | 16.000 | 38,728.000 |
| Set-aside area (%) | 95 | 0.073 | 0.116 | 0.000 | 0.867 |
| *Certified FSC* | | | | | |
| Set-aside area (ha) | 57 | 145.027 | 281.847 | 0.600 | 1,378.000 |
| Productive forest (ha) | 57 | 1,869.737 | 3,115.004 | 7.000 | 16,145.000 |
| Set-aside area (%) | 57 | 0.083 | 0.058 | 0.004 | 0.242 |
| *Certified PEFC* | | | | | |
| Set-aside area (ha) | 131 | 106.525 | 582.855 | 0.500 | 5,343.000 |
| Productive forest (ha) | 131 | 674.328 | 1,592.852 | 8.000 | 12,883.000 |
| Set-aside area (%) | 131 | 0.101 | 0.142 | 0.003 | 0.987 |

*Note:* FSC, Forest Stewardship Council; PEFC, Programme for the Endorsement of Forest Certification.

In Panel A of Appendix Table A2, we observe that even when the groups are statistically different in many of the characteristics, the magnitude of the difference is substantial only for the covariates related to the geographic characteristics of the plots and participation in forest associations. In particular, there are substantial differences in the quality of the soil, and there is lower road density in the control group. From this analysis, we can conclude that because some of the covariates differ substantially between the treated and control groups, the conventional ordinary least squares (OLS) analysis could be sensitive to specification and outliers (Imbens 2015).

Similar patterns can be seen for the regeneration monitoring dataset analysis (see Appendix Table A3), where the magnitude of the difference is substantial only for the covariates related to road density and participation in forest associations.

To account for the potential selection bias, we first fit an OLS regression in which we control for observed heterogeneity by including the covariates:

$$Y_{ijt} = \beta_1\ Treatment_i + \sum_{l=1}^{L} \alpha_l Z_{il} + \sum_{m=1}^{M} \delta_m X_{im} + \gamma_j + \eta_t + u_{ijt},$$

where $Y_{ijt}$ is the outcome for the $i$th plot located in the $j$th county felled in year $t$. For the analysis of the environmentally important areas, we test different definitions for the outcome: the cleared area (measured in absolute and relative terms) and the noncompliance rate. As the cleared area follows a log-normal distribution, we also show the results with the inverse hyperbolic sine transformation as outcome (see footnote 7). Note that by defining the cleared area in relative terms, we include only those plots with a positive initial value of environmentally important areas. For the analysis of the number of trees and high stumps left after felling, we define the dependent variable as number of trees left per cleared hectare, and we also consider the noncompliance rates.

Both in the case of the analysis of environmentally important areas and in the case of the number of trees and high stumps left, the coefficient of interest is $\beta_1$, which measures impact of certification on the outcome. *Treatment* is a dummy variable taking the value 1 if the plot is certified and otherwise 0, according to the previously defined treatment groups. $\mathbf{Z}$ is a vector of $L$ forest owner characteristics, and $\mathbf{X}$ is a vector of $M$ plot characteristics. $\gamma_j$, $\eta_t$ are county and felling year fixed effects, respectively, and $u_{ijt}$ is the error term. We estimate this model with OLS, where $\beta_1$ captures the average treatment effect, but the results also hold with nonlinear probability models (probit). We also present the average treatment effect on the treated (ATT) with OLS, following Wooldridge (2010). The ATT estimator finds the average treatment effect for the certified plots and is useful for comparing the results with the matching estimator (see below).

In addition to the OLS estimator, we use matching to construct a control group that mimics the treated group in all relevant observable characteristics. This matched control group is intended to resemble the counterfactual, in other words, what would have happened had the treated group not received the certification. One advantage of matching over OLS is that the results are less sensitive to the specification of the functional form (see, e.g., Imbens 2015).

Following Imbens (2015), we first preprocess the data in order to obtain a more balanced sample. This will ensure that the results are more robust with any estimator (see, e.g., Rosenbaum and Rubin 1983; Imbens 2015). We trim the sample based on the propensity score matching estimated using one neighbor, a caliper of 0.01, and all covariates listed in Appendix Tables A2 and A3 in addition to county and year fixed effects. We choose this caliper value to select the observations that are closest in terms of propensity score in order to reduce the selection bias (Caliendo and Kopeinig 2008). In trimming the sample, we also drop treatment observations whose propensity score is higher than the maximum or less than the minimum propensity score of the controls.

This procedure dropped 54 (22%) and 66 (11%) treated observations for the consideration monitoring and the regeneration monitoring datasets, respectively.[13] In both cases, observations with a propensity score higher than 0.94 were dropped in order to ensure overlap (see Appendix Figures B2 and B3). For the main results we present the results for matching with trimming, but in Appendix Tables B2 and B3 we show the results for the full sample as robustness tests, as well as for alternative methods for trimming the sample and different values of the caliper.

Although in estimating the selection into the treatment model we are primarily interested in obtaining the propensity score values to trim the sample, the results can shed some light on what explains the certification decision. We present the coefficients for treatment assignment in Appendix Table B4, where we show there is substantial geographic and time variation in the certification rates. In particular, certification is more likely in southern counties and in more recent years. In addition, participation in a forest association is an important predictor, with members having 23% higher probability to be certified compared to nonparticipants.

We then use bias-adjusted covariate matching (CVM) on the new sample obtained after trimming to estimate the ATT (Imbens 2015). For the CVM we consider one neighbor, and observations are matched using the diagonal matrix of the inverse sample standard errors of the covariates. By using bias-adjusted matching, the estimator will remove some of remaining bias that could result from having unbalanced covariates after matching through a regression on the same set of covariates (Abadie and Imbens 2011). Compared to other matching estimators, CVM has the advantage that the standard errors are consistently estimated (Abadie and Imbens 2006).

[13] In addition, 19 treated observations were dropped in the consideration monitoring dataset and 15 in the regeneration monitoring dataset due to the empty cells problem. In particular, these are treated observations in counties where there are no untreated observations.

Matching as a strategy to control for covariates is motivated by the assumption that conditional on observed characteristics, the potential outcomes are independent of the treatment assignment. We verify the plausibility of the unconfoundedness assumption in Appendix Table B6. Also, we verify the sensitivity of our results to the presence of a potential unobserved factor by estimating the Rosenbaum bounds (Rosenbaum 2002), in Appendix Table B7.

## 4. Results

### Forest Certification and Conservation of Environmentally Important Areas

Table 4 presents the main results. In Panel A we address the question: Does forest certification affect the probability and magnitude of compliance with preservation of environmentally important areas during the felling? In columns we compare the results obtained with different estimation strategies, and in rows we specify different definitions for the outcome and for the set of control variables included in the model.

In the first column and row of Table 4, we show the difference in means for the noncompliance rate between the treatment and the control. We observe that certified plots have a 3.7% lower probability of noncompliance compared with noncertified plots, but this difference is not statistically significant. Similarly, we present this test for the other outcomes and observe that although certified plots have a smaller damaged area both in absolute and relative terms, these differences are not statistically different from zero either.

In fact, when we account for the spatial and temporal variability, we find higher but nonsignificant noncompliance rates and magnitudes in the certified group. This result holds when we add additional observed characteristics that could confound the effect, when computing the ATT, and with matching (columns 2 to 5). In Appendix Table B2 we show that these findings are robust whether we trim the sample or not, and to the caliper used to preprocess the data. We note that the magnitude of the coefficients is small in all estimation methods. Hence, even in a scenario of lack of statistical power to detect an effect given the sample size, the magnitudes of the effects suggest a small difference between treated and control groups.

In Appendix Table A4, we look at the effects of each certification standard separately and test whether there are any differences between them. We also test whether holding both certifications simultaneously has an effect on the outcomes. We compare the treatment effects obtained by OLS including all covariates. We find the same results: there is no evidence that FSC or PEFC certification plots decrease the probability or the magnitude of noncompliance. Also, we observe no difference between the labels.

Thus, our analysis shows no evidence to support the hypothesis that forest certification increases the preservation of environmentally important areas during felling. Furthermore, we find no difference between certification labels. This might not be a surprising result, since the certification requirements by FSC and PEFC are rather similar and the requirements of both FSC and PEFC coincide with those established by the Swedish Forestry Act. This raises, however, questions regarding the supposed added value of multiple certifications and label competition for overall environmental protection. Further, there is the question of the overall compliance with the Swedish Forestry Act and of the reliance on certification schemes to provide additional economic incentives to comply with environmental regulations. Our results show that such incentives are marginal and ineffective.

### Forest Certification and the Number of Trees and High Stumps Left

To analyze the effects of forest certification on the number of trees and high stumps left, we conduct a similar analysis as in the previous section. We present the results in Panel B of Table 4, where we present the results for the number of trees left and the noncompliance rates, with both OLS and matching estimates on the full and trimmed sample. A simple difference in means test shows that more trees are left and noncompliance is lower in certified plots. However, these differences vanish

**Table 4**
Effects of Forest Certification

| Dependent Variable | Difference in Means | OLS (Year and County FE) | OLS (All Covariates) | ATT with OLS (All Covariates) | ATT with CVM on Trimmed Sample |
|---|---|---|---|---|---|
| *A. Consideration Monitoring Dataset* | | | | | |
| Noncompliance rate | –0.037 | 0.013 | 0.01 | 0.013 | 0.072 |
| Standard error | 0.037 | 0.042 | 0.045 | 0.052 | 0.086 |
| Observations | 763 | 763 | 763 | 763 | 295 |
| *R*-squared | 0.001 | 0.134 | 0.161 | 0.213 | |
| Area cleared (ha) | –0.057 | 0.043 | 0.038 | 0.061 | 0.017 |
| Standard error | 0.069 | 0.093 | 0.086 | 0.060 | 0.115 |
| Observations | 763 | 763 | 763 | 763 | 295 |
| *R*-squared | 0.001 | 0.029 | 0.091 | 0.162 | |
| Area cleared (IHS) | –0.040 | 0.007 | 0.000 | 0.014 | –0.018 |
| Standard error | 0.025 | 0.033 | 0.032 | 0.028 | 0.057 |
| Observations | 763 | 763 | 763 | 763 | 295 |
| *R*-squared | 0.003 | 0.041 | 0.109 | 0.201 | |
| Area cleared (%) | –0.011 | 0.019 | 0.023 | 0.030 | 0.075 |
| Standard error | 0.028 | 0.033 | 0.035 | 0.037 | 0.086 |
| Observations | 715 | 715 | 715 | 715 | 273 |
| *R*-squared | 0.000 | 0.067 | 0.085 | 0.170 | |
| *B. Regeneration Monitoring Dataset* | | | | | |
| Trees left/ha | 1.498** | 0.679 | 0.888 | –0.778 | –2.198 |
| Standard error | 0.691 | 0.828 | 0.894 | 1.062 | 1.451 |
| Observations | 1,065 | 1,065 | 1,065 | 1,065 | 754 |
| *R*-squared | 0.004 | 0.146 | 0.161 | 0.216 | |
| High stumps left/ha | 0.407*** | 0.237 | 0.106 | 0.183 | 0.126 |
| Standard error | 0.143 | 0.149 | 0.156 | 0.210 | 0.261 |
| Observations | 1,065 | 1,065 | 1,065 | 1,065 | 754 |
| *R*-squared | 0.007 | 0.155 | 0.169 | 0.200 | |
| *Noncompliance Rate* | | | | | |
| Trees left/ha | –0.086*** | –0.052* | –0.056* | –0.015 | 0.038 |
| Standard error | 0.028 | 0.030 | 0.033 | 0.042 | 0.053 |
| Observations | 1,065 | 1,065 | 1,065 | 1,065 | 754 |
| *R*-squared | 0.008 | 0.110 | 0.125 | 0.157 | |
| High stumps left/ha | –0.053** | –0.024 | –0.000 | –0.012 | 0.020 |
| Standard error | 0.024 | 0.025 | 0.027 | 0.036 | 0.045 |
| Observations | 1,065 | 1,065 | 1,065 | 1,065 | 754 |
| *R*-squared | 0.004 | 0.124 | 0.136 | 0.168 | |

*Note:* All covariates include variables listed in Appendix Tables A2 and A3, respectively, and county and year fixed effects. The sample includes 21 counties and 13 years. Reported standard errors are robust (White 1980) for OLS, and Abadie and Imbens (2006, 2011) for covariate matching. ATT, average treatment effect on the treated; CVM, covariate matching; FE, fixed effects; IHS, inverse hyperbolic sine transformation; OLS, ordinary least squares.
$p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

once we account for the spatial and time variation. When controlling for additional covariates and computing the matching estimators, we consistently find zero effect of certification on the outcomes.

Together, these results suggest that there is no evidence that certification has a significant effect on the noncompliance rate or on the number of trees or high stumps left. This is a disappointing result, because while scientific studies have shown that there is no generally accepted single threshold value for the proportion of deciduous trees required for conserving viable populations of species (Johansson et al. 2013), nevertheless, most studies suggest thresholds that are much higher than those established by the Swedish Forestry Act and certification schemes (see, e.g., Bütler et al. 2004; Ranius and Fahrig 2006). The lax requirements by certification schemes and the lack of compliance with them can have significant detrimental effects on the survival of species dependent on continuous input of dead wood at stand level. Moreover, our results suggest that in order to mitigate the effects of forest management on biodiversity and improve the situation for threatened forest species, the levels in the Swedish Forestry Act and certification standards need to be adapted to the current knowledge on habitat demands and thresholds for demanding species.

## Forest Certification and Set-Aside Areas

Finally, our results show that on average, certified owners set aside 8.8% of the land. This share is higher than the 5% required by the certification schemes but is not statistically different from the 7.3% left by noncertified forest owners (see Appendix Table A5). Furthermore, we explore whether there are differences between certification types. FSC-certified forest owners set aside 0.9% more area than noncertified forest owners; the corresponding figure for PEFC-certified forest owners is 2.8%. However, these differences are again not statistically significant at conventional levels—even when we control for geographic location by including the forest area and county fixed effects—pointing to a lack of incremental effect of forest certification on the size of the areas set aside for conservation purposes. This is, again, a disappointing result, since fragmentation is a major reason for the declining biodiversity in forest ecosystems (Haddad et al. 2015). Besides decreasing habitat area, fragmentation results in increasing isolation of suitable habitats, increasing exposure to negative edge effects, and reducing the provision of forest ecosystem services (see, e.g., Chaplin-Kramer et al. 2015).

## Robustness Checks

### *Sample Selection Bias*

We test whether selection bias affects our results, as roughly half of the sample did not complete the survey through which we obtained the forest owners' certification status. To account for the systematic differences in the demographic characteristics of the forest owners in our sample with respect to the original consideration monitoring and regeneration monitoring datasets, we use the two-stage Heckman model (Heckman 1979) for both datasets. We first use the entire sample of forest owners to estimate the probability that the survey would be completed. The dependent variable takes the value of 1 if the survey was completed and zero otherwise. As explanatory variables, we include demographic variables that could explain the response rate and that are available for the entire sample, namely, gender, age, and owner present. In the second stage, we correct for selectivity bias by including the inverse Mills ratio obtained from the first stage in the deforestation equation, all control variables related to the geographic characteristics, participation in forest association, education, experience as forest owner, and county and year fixed effects. The assumption is that the variables gender, age, and owner affect the outcomes only through their role in the sample selection, conditional on the variables included in the second stage. This is a reasonable assumption, as we are already controlling for characteristics that determine environmental awareness and access to information, such as education, experience, and participation in forest associations.

We present the results in Appendix Table B5, where we show that for both analyses, the Heckman selection model finds an effect of the certification almost identical to that of OLS with all covariates (column 3 in Table 4). Furthermore, in all cases the lambda parameter is not significantly different from zero, which suggests that unobserved factors that make participation in the survey more likely are not associated with forest management.

### *Unconfoundedness*

Following the test proposed by Imbens (2015), we perform an analysis of the plausibility that our matching method meets the unconfoundedness assumption. We test whether the method results in a sample that is as good as random conditional on the covariates. In Appendix Table B6 we present the treatment effect for three "pseudo-outcomes": area of the plot, gender, and age. We follow the same procedure as presented in Section 3 for the core results. First, we preprocess the sample matching on the propensity score obtained with the remaining covariates, and then we use CVM on the trimmed sample to obtain the ATT, which is known a priori to be zero. For the consideration monitoring dataset analysis, we observe that we cannot reject the null hypothesis of zero effect on all the pseudo-outcomes with the full sample, whereas with CVM after trimming, all three "pseudo–causal effects" are not statistically different from zero. This result indicates that trimming the sample indeed makes the results more robust to the unconfoundedness assumption. For the regeneration monitoring dataset analysis we find that the unconfoundedness assumption is plausible both for the full and the trimmed sample.

*Sensitivity Test for Selection on Unobserved Factors*

We report the Rosenbaum bounds (Rosenbaum 2002) for hidden bias in Appendix Table B7, following the routine for binary outcomes proposed by Becker and Caliendo (2007). This analysis shows how strongly an unobserved factor must affect the selection into the treatment in order to invalidate the matching estimates. When gamma is equal to 1, we are under the no hidden bias scenario, and the test statistic shows that there is no effect of certification on the noncompliance rate. If we have a negative unobserved selection, so that compliers do not get certified, our estimated treatment effect underestimates the true treatment effect. In this case the Qmh statistic is too low and should be adjusted upward. Appendix Table B7 shows the Mantel-Haenszel statistic for the assumption of underestimation of treatment effect and the corresponding significance level. Overall, we can see that our analysis is fairly robust, as at relatively small values of gamma the result of zero impact holds. For the analysis of the effect of the certification on the noncompliance with the environmentally important areas, our estimates are robust to unobserved factors that increase the odds of certification by a factor of 2.2. Similarly, our analysis of the effects of certification on the compliance with the number of trees left per cleared hectare is robust to unobserved factors that increase the odds of certification by a factor of 1.8.

## 5. Conclusions

Reconciling timber production with biodiversity protection in private forest is a challenge since the supply of biodiversity usually goes unrewarded by markets, and protection of biodiversity comes at an opportunity cost to forest owners. This makes it unlikely that biodiversity protection will be achieved in the absence of further incentives to compensate forest owners for the potential productivity losses. Forest certification has been proposed as an alternative to provide assurance to a mass of environmentally concerned consumers that certified forest products come from a forest managed to maintain and/or enhance biodiversity protection.

In this paper, we investigate the effects of the two main forest certification schemes in Sweden—FSC and PEFC—on three key environmental outcomes embedded in the certification standards, namely, environmentally important areas preserved during felling, number of trees and high stumps left after felling, and area set aside for conservation purposes. These environmental outcomes are relevant to avoid forest degradation and to ensure sustainable management of boreal forests. The joint consideration of all these environmental outcomes delivers a more complete assessment of the overall environmental impact of certification.

We found that 64% of the inspected plots do not comply with environmental considerations, implying that most sensitive habitats are not saved during felling. Furthermore, our main result is that, compared to the performance of similar noncertified forest owners, certification has not led to any additional improvements in these outcomes, and hence it has not contributed to reducing forest degradation in Sweden.

We conclude that although certification as a sustainable forest management policy is rewarded with price premiums and improved market access, certified forest owners are not significantly more likely to preserve areas of high conservation value or to increase the magnitude of the areas that are set aside for conservation purposes. Furthermore, there is no difference between the certification schemes, which is not surprising given the similarity of the standards. In contrast, the geographic location of the plots, soil productivity, and participation in forest associations seem to be key factors explaining compliance with certification standards and the selection into treatment.

Our results are robust to the model choice and to various alternative definitions of the treatment and outcome variables. They contribute to the evidence that forest certification is generally not associated with increased environmental benefits (see, e.g., Blackman, Goff, and Rivera Planter 2015; Panlasigui et al. 2015). Nevertheless, in contrast to previous studies that have focused on deforestation, our study provides evidence of the lack of effect of certification on avoided degradation vis-à-vis the performance of comparable noncertified forest owners.

Furthermore, while previous studies have analyzed the effects of certification in the context of developing countries, we focus on the case of Sweden, a developed country with the largest total area of certified forest in Western Europe. We acknowledge that national forest certification standards are the result of voluntary negotiations among stakeholders with different goals and power, and, hence, are context dependent, because countries and regions have different forest-industrial regimes. Nevertheless, the fact that empirical evidence has shown that the effects on certification are limited both in the context of developing and developed countries raises concerns about the role of forest certification as a tool to promote sustainable forest management practices.

Our results indicate that, if forest certification in Sweden is to have an effect, it needs to become more stringent, not only when it comes to the standards but also in terms of monitoring and enforcement, because neither certified nor noncertified owners are in compliance with the environmental outcomes studied in this paper.

Indeed, even though identifying the mechanisms that explain our results goes beyond the scope of our analysis, the high rates of noncompliance might be the result of the lack of clear definitions and quantifiable measures in the Swedish Forestry Act regarding what constitutes sustainable forest management. Although the Swedish Forestry Act states that preservation of natural and environmental values should be prioritized to the same extent as forest production values, the lack of clear and quantifiable measures makes it difficult for the certifiers to implement standards that are stringent enough and legitimized by society.

## Acknowledgments

Financial support from Adlerbertska and the research program Biodiversity and Ecosystem Services in a Changing Climate (BECC) is gratefully acknowledged. Laura Villalobos also acknowledges funding from the Swedish International Development Cooperation Agency (SIDA). We are grateful for valuable comments from Måns Söderbom, Allen Blackman, Erin Sills, Thomas Sterner, Andreas Kontoleon, Carol Newman, Peichen Gong, and the anonymous referees. We also thank Andreas Eriksson and Patrik Olsson at the Swedish Forest Agency for kindly providing us with access to the data.

## References

Abadie, Alberto, and Guido W. Imbens. 2006. "Large Sample Properties of Matching Estimators for Average Treatment Effects." *Econometrica* 74 (1): 235–67.

———. 2011. "Bias-Corrected Matching Estimators for Average Treatment Effects." *Journal of Business and Economic Statistics* 29 (1): 1–11.

Becker, Sascha O., and Marco Caliendo. 2007. "Mhbounds: Sensitivity Analysis for Average Treatment Effects." IZA Discussion Paper No. 2542. Bonn, Germany: Institute for the Study of Labor (IZA).

Blackman, Allen, Leonard Goff, and Marisol Rivera Planter. 2015. "Does Eco-certification Stem Tropical Deforestation? Forest Stewardship Council Certification in Mexico." RFF Discussion Paper 15-36. Washington, DC: Resources for the Future.

Blackman, Allen, and Jorge Rivera. 2011. "Producer-Level Benefits of Sustainability Certification." *Conservation Biology* 25 (6): 1176–85.

Bütler, R., P. Angelstam, P. Ekelund, and R. Schlaepfer. 2004. "Dead Wood Threshold Values for the Three-Toed Woodpecker Presence in Boreal and Sub-alpine Forest." *Biological Conservation* 119 (3): 305–18.

Caliendo, Marco, and Sabine Kopeinig. 2008. "Some Practical Guidance for the Implementation of Propensity Score Matching." *Journal of Economic Surveys* 22 (1): 31–72.

Chaplin-Kramer, Rebecca, Ivan Ramler, Richard Sharp, Nick M. Haddad, James S. Gerber, Paul C. West, Lisa Mandle, Peder Engstrom, Alessandro Baccini, Sarah Sim, et al. 2015. "Degradation in Carbon Stocks Near Tropical Forest Edges." *Nature Communications* 6: 10158.

European Commission. 2011. *Buying Green! A Handbook on Green Public Procurement*, 2nd ed. Luxembourg: Publications Office of the European Union. Available at http://ec.europa.eu/environment/gpp/pdf/handbook.pdf (accessed October 7, 2015).

Folke, Carl, Steve Carpenter, Brian Walker, Marten Scheffer, Thomas Elmqvist, Lance Gunderson, and C. S. Holling. 2004. "Regime Shifts, Resilience, and Biodiversity in Ecosystem Management." *Annual Review of Ecology, Evolution, and Systematics* 35: 557–81.

Food and Agriculture Organization of the United Nations (FAO). 2015. Global Forest Resources Assessment 2015: *How Are the World's Forests Changing?* Rome: FAO. Available at www.uncclearn.org/sites/default/files/inventory/a-i4793e.pdf.

Forest Stewardship Council (FSC). 2009. *FSC Standard for Group Entities in Forest Management Groups*. Bonn, Germany: FSC. Available at https://se.fsc.org/preview.fsc-std-30-005-fm-group.a-605.pdf (accessed October 5, 2015).

———. 2010. *Swedish FSC Standard for Forest Certification Including SLIMF Indicators*. Bonn, Germany: FSC. Available at ic.fsc.org/download.fsc-std-swe-02-02-2010-en.1703.htm (accessed February 6, 2016).

———. 2013. *Din skog syns bättre om den märks*. Bonn, Germany: FSC. Available at https://se.fsc.org/preview.din-skog-syns-baettre-om-den-maerks-information-till-mindre-markaegare.a-682.pdf (accessed October 5, 2015).

Gauthier, S., P. Bernier, T. Kuuluvainen, A. Shvidenko, and D. Schepaschenko. 2015. "Boreal Forest Health and Global Change." *Science* 349 (6250): 819–22.

Haddad, Nick M., Lars. A. Brudvig, Jean Clobert, Kendi F. Davies, Andrew Gonzalez, Robert D. Holt, Thomas E. Lovejoy, Joseph O. Sexton, Mike P. Austin, Cathy D. Collins, et al. 2015. "Habitat Fragmentation and Its Lasting Impact on Earth's Ecosystems." *Science Advances* 1 (2): e1500052.

Heckman, James J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica* 47 (1): 153–61.

Heilmayr, Robert, and Eric F. Lambin. 2016. "Impacts of Nonstate, Market-Driven Governance on Chilean Forests." *Proceedings of the National Academy of Sciences U S A* 113 (11): 2910–15.

Hirschberger, Peter. 2005. *The Effects of FSC-Certification in Sweden: An Analysis of Corrective Action Requests*. WWF European Forest Programme. Gland, Switzerland: WWF.

Imbens, Guido W. 2015. "Matching Methods in Practice: Three Examples." *Journal of Human Resources* 50 (2): 373–419.

Imbens, Guido W., and Donald B. Rubin. 2007. *Causal Inference: Statistical Methods for Estimating Causal Effects in Biomedical, Social, and Behavioral Sciences*. Cambridge: Cambridge University Press.

Johansson, Johanna, and Gun Lidestav. 2011. "Can Voluntary Standards Regulate Forestry? Assessing the Environmental Impacts of Forest Certification in Sweden." *Forest Policy and Economics* 13 (3): 191–98.

Johansson, Therese, Joakim Hjältén, Johnny de Jong, and Henrik von Stedingk. 2013. "Environmental Considerations from Legislation and Certification in Managed Forest Stands: A Review of Their Importance for Biodiversity." *Forest Ecology and Management* 303: 98–112.

Miteva, Daniela A., Colby J. Loucks, and Subhrendu K. Pattanayak. 2015. "Social and Environmental Impacts of Forest Management Certification in Indonesia." *PLOS One* 10 (7): e0129675.

Nordlind, E., and L. Östlund. 2003. "Retrospective Comparative Analysis as a Tool for Ecological Restoration: A Case Study in a Swedish Boreal Forest." *Forestry* 76 (2): 243–51.

Panlasigui, Stephanie, Jimena Rico-Straffon, Jennifer Swenson, Colby J. Loucks, and Alexander Pfaff. 2015. "Early Days in the Certification of Logging Concessions: Estimating FSC's Deforestation Impact in Peru and Cameroon." Duke Environmental and Energy Economics Working Paper EE 15-05. Durham, NC: Duke University.

Prosilva Skogscertifiering AB. 2015. *Kostnader*. Uppsala, Sweden: Prosilva Skogscertifiering AB. Available at http://skogscertifiering.se/valkommen-skogsagare/kostnader/ (accessed October 5, 2015).

Rametsteiner, Ewald, and Markku Simula. 2003. "Forest Certification: An Instrument to Promote

Sustainable Forest Management?" *Journal of Environmental Management* 67 (1): 87–98.

Ranius, Thomas, and Lenore Fahrig. 2006. "Targets for Maintenance of Dead Wood for Biodiversity Conservation Based on Extinction Thresholds." *Scandinavian Journal of Forest Research* 21 (3): 201–8.

Romero, Claudia, Francis E. Putz, Manuel R. Guariguata, Erin O. Sills, Paolo O. Cerutti, and Guillaume Lescuyer. 2013. *An Overview of Current Knowledge about the Impacts of Forest Management Certification: A Proposed Framework for Its Evaluation*, Vol. 99. Bogor, Indonesia: CIFOR.

Rosenbaum, Paul R. 2002. "Observational Studies." In *Observational Studies*, 2nd ed., 1–17. NewYork: Springer-Verlag.

Rosenbaum, Paul R., and Donald B. Rubin. 1983. "The Central Role of the Propensity Score in Observational Studies for Causal Effects." *Biometrika* 70 (1): 41–55.

Royal Swedish Academy of Agriculture and Forestry (RSAAF). 2015. *Forests and Forestry in Sweden*. Stockholm: Royal Swedish Academy of Agriculture and Forestry.

Söderström, Bo. 2009. "Effects of Different Levels of Green- and Dead-Tree Retention on Hemi-boreal Forest Bird Communities in Sweden." *Forest Ecology and Management* 257 (1): 215–22.

Swedish Forest Agency. 2010. *Miljöhänsyn vid föryngringsavverkning: Resultat från Skogsstyrelsens rikspolytaxinventering (R0/R1), avverkningssäsongerna 1998/1999–2006/2009*. Jönköping: Swedish Forest Agency.

———. 2014. *Swedish Statistical Yearbook of Forestry*. Jönköping: Swedish Forest Agency.

Thompson, Ian D., Manuel R. Guariguata, Kimiko Okabe, Carlos Bahamondez, Robert Nasi, Victoria Heymell, and Cesar Sabogal. 2013. "An Operational Framework for Defining and Monitoring Forest Degradation." *Ecology and Society* 18 (2): 20.

Timonen, Jonna, Lena Gustafsson, Janne S. Kotiaho, and Mikko Mönkkönen. 2011. "Hotspots in Cold Climate: Conservation Value of Woodland Key Habitats in Boreal Forests." *Biological Conservation* 144 (8): 2061–67.

United Nations Economic Commission for Europe and Food and Agriculture Organization of the United Nations (UNECE/FAO). 2012. *Forest Products Annual Market Review, 2011–2012*. New York: UNECE/FAO. Available at www.unece.org/fileadmin/DAM/timber/publications/FPAMR_2012.pdf.

Van der Werf, G. R., D. C. Morton, R. S. DeFries, J.G.J. Olivier, P. S. Kasibhatla, R. B. Jackson, G. J. Collatz, and J. T. Randerson. 2009. "$CO_2$ Emissions from Forest Loss." *Nature Geoscience* 2 (11): 737–38.

Vincent, Jeffrey R. 2016. "Impact Evaluation of Forest Conservation Programs: Benefit-Cost Analysis, without the Economics." *Environmental and Resource Economics* 63 (2): 395–408.

White, Halbert. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48 (4): 817–38.

Wikberg, Sofie, Karin Perhans, Claes Kindstrand, Line Boberg Djupström, Mattias Boman, Leif Mattsson, Leif Martin Schoeder, Jan Weslien, and Lena Gustafsson. 2009. "Cost-effectiveness of Conservation Strategies Implemented in Boreal Forests: The Area Selection Process." *Biological Conservation* 142 (3): 614–24.

Wooldridge, Jeffrey M. 2010. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.