Evaluating Impacts of FSC on Tree-Cover Outcomes within Russia's Far East Region

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Abstract

Certification of forest management in concessions has risen, with promises of better returns for producers who implement practices preferred by consumers. Evidence about the impact of Forest Stewardship Council (FSC) certifications also has risen – at least for the tropics. We provide the first rigorous test of FSC impact in boreal forests by examining reductions in both forest and Intact Forest Landscapes (IFL) in Russia's Far East region in 2013-2016 (IFL is computed from forest yet given its spatial definition we see it as a distinct outcome). Forest and IFL shifts are concentrated in 10% of *kvartals*, i.e., smaller management units. The drop in IFL over this period is a bit smaller in FSC kvartals, though some controls for other factors make that difference insignificant. In contrast, the drop in forest is a bit larger in FSC kvartals, until 2016. Our estimates of FSC impacts could be shifted by controls for more differences between FSC and NonFSC kvartals – e.g., concerning the sites and firms. Our analyses document limited impacts for this initial FSC period, while simultaneously highlighting limits on the available data for sites, firms, dates, outcomes, and other regions.

Executive Summary

Certification of forest management in logging concessions has been rising. It is one intervention intended to reduce impacts from logging: producers implement practices preferred by consumers, on the promise of higher total returns from their harvests. Studies examining the effect of Forest Stewardship Council (FSC) certification have also been rising, of late, yet the evidence is limited to select case studies in tropical forests. We offer the first rigorous test of FSC's impact in boreal forests by examining reductions in forest and Intact Forest Landscapes (IFL) in Russia's Far East region for 2013-2016, within forest *kvartals* (smallest forest-management units). This assessment uses the best available information on forest changes following the start of certifications in 2012.

We considered IFL and forest reduction outcomes separately, as they represent unique measures. To examine forest-cover change, we employed a widely used global forest-cover-change dataset. Distinct from that measure of the total extent of the forest, IFL is defined by large, unfragmented forest patches. IFL aims to reflect the fact that spatial configurations of forests determine habitat suitability for many species of interest. We find that these IFL outcomes can be sensitive even to small forest reductions, and to reductions outside of the kvartal in question. For some kvartals in the Far East region, e.g., a 100% IFL reduction occurred where zero reduction in forest occurred.

Since logging activity tends to be spatially concentrated within a concession, it is not surprising that we found that almost all reductions in Far East forests occurred in 10% of kvartals. Further, almost all IFL reductions occur in 10% of kvartals (a distinct 10% from for forest). We focus on these two groups of kvartals where, respectively, the greatest changes in each outcome occurred.

We document quite limited differences for FSC for this initial period after certification. For the few firms certified by FSC at known dates, FSC kvartals had slightly lower IFL reductions, for this period – though that estimated impact from FSC is not statistically significant for all of our forms of controlling for other factors. In contrast, the FSC kvartals experienced a larger decrease in forest (though not in 2016). Further controls for site and firm differences may affect estimates.

Data limitations with respect to the study regions, the units of observation and the firms involved offer opportunities for further study. Within the Far East, given that relatively few firms manage multiple concessions, each containing multiple kvartals, the unit of observation could be shifted and could affect conclusions, in particular concerning spatial patterns and statistical significance. Incorporating other potentially important firm characteristics, such as annual logging volumes or export destinations, could affect our comparisons and, thus, estimates. More confirmed dates for FSC certifications, and Non-FSC leases, would increase our ability to compare across time. And getting data from Russia's Central and Northwest logging regions would also add understanding.

Our outcomes measures also have limitations and could not possibly capture all of the outcomes of keen interest to actors on the ground. Global forest-change data, e.g.: identify the single 'loss' year for each pixel associated with the most severe forest-loss event documented; do not include attributions to anthropogenic versus natural causes (e.g., fire); and do not consider degradation or take into account species, within forest composition. Additional information would be necessary also to consider spatially specific forest priorities, such as where the types of changes in forests that we document would be particularly consequential for biodiversity and flows of ecoservices.

Introduction

Around the globe, forests have been subject to significant pressures for conversion − driven by a desire for production in a set of sectors such as mining, ranching, and industrialized agriculture – that is facilitated by investments in infrastructure such as roads (DeFries et al. 2010; Laurance et al. 2001; Swenson et al. 2011). Environmental consequences for forests have been significant, as have been consequences from forest-cover change for biodiversity (Murphy and Romanuk 2014; Tilman et al. 2017), global climate and hydrologic processes (Foley, 2005), erosion, degradation of water resources and species extinctions (see, e.g., Laurance 2009; Van der Werf et al. 2009).

The largest conservation response, in terms of area, has been to create new protected areas (PAs) around the world (Jenkins & Joppa 2009), despite resistance based on the desired for production that affects PA location (Joppa & Pfaff 2009) and duration (Pack et al. 2016; Tesfaw et al. 2018). Conservation on private lands and leased public lands has been suggested as one complement to PAs (RESOLVE 2011). In forested regions, one might create incentives for firms to lower their logging impacts by adjusting how they manage forest concessions, given consumers' and more generally citizens' interests (consider the United States' amendment of The Lacey Act of 2008, European Union Timber Regulations of 2010 and Australian Illegal Logging Prohibition Act of 2012). Certification based on verification of adjusted practices could help to provide incentives.

Many forest concessions have been voluntarily certified by Forest Stewardship Council (FSC), founded to promote "environmentally appropriate, socially beneficial, and economically viable management of the world's forests" (FSC 2015). FSC certification is one market-based solution within the suite of tools for avoiding or reducing detrimental impacts of forest change (Agrawal, Chhatre, & Hardin, 2008; Lambin et al., 2018) and the best recognized standard for responsible forestry (FSC International, n.d.). Over 201 million hectares are certified under FSC standards.

These certifications have included consideration of issues particularly focused on species habitat. For instance, FSC International recently passed a motion to change its standard for considering 'Intact Forest Landscapes' (IFLs) from being a type of 'high conservation value forest' (HCVF) to requiring "protection measures (for example, set-asides, legal protected areas, conservation reserves, deferrals, community reserves, indigenous protected areas etc.) ensuring management for intactness" in mapped IFL areas (Forest Stewardship Council, 2014). This follows an interest in going beyond gross forest-cover change to take into account spatial configurations of change. IFL are defined by a minimum area of 500 km^2 where forest or naturally treeless ecosystems do not have detectable evidence of human activity (Potapov et al., 2017) − motivated by a growing body of research demonstrating the value from large tracts of forest for maintaining biodiversity and ecosystem services. It has gained considerable traction within the conservation community.

For this and other outcomes, whether FSC has had impacts is debated. Practices and outcomes vary across certified concessions (Burivalova et al. 2016; Counsell and Loraas 2002; Nebel et al. 2005) yet rigorous assessment of impacts has been quite limited (Romero et al. 2018). The scale of FSC alone, and diversity of settings covered, challenges the assessment of impacts, however. Rigorous fieldwork at regular intervals for all certified concessions, plus uncertified concessions and non-concession forests to allows comparisons to estimate FSC impact, would be very costly.

Yet even for very remote locations of developing countries, we now have cost-efficient remotely sensed data and derived data products, produced regularly with global coverage over many years.

The most straightforward remotely sensed outcomes measure to consider the effects of different land-use interventions is the rate of forest loss. The recent creation of global forest loss products such as Hansen et al. (2013, featured in GlobalForestWatch.org) or Sexton et al. (2013) provide consistently mapped remotely sensed estimates of forest losses, globally, at a fine spatial scale. This has been a boon to estimation of some FSC impacts (yet below we note some limitations).

Recent studies demonstrate the feasibility of using such measures of forest losses for inferences concerning FSC impacts (Blackman et al. 2015; Heilmayr and Lambin 2016; Miteva et al. 2015, Panlasigui et al. 2018, Rico et al. 2018) concerning forest impacts from FSC forest management. With the exception of Heilmayr and Lambin for Chile, these studies find little, if any, reductions in deforestation due to FSC − while emphasizing that impacts vary by setting even in a country.

Despite that acknowledgement of global settings heterogeneity, studies of impacts from FSC or other forest-management certification have focused upon the tropics, chiefly in South American and Southeast Asian forests with mixed results (Lambin et al., 2018), even though boreal regions have recently undergone relatively rapid changes in forest cover − due to both fires and forestry (Achard, 2002; Hansen et al., 2013a). Assessing how certification affects boreal forest outcomes, which clearly may be subject to driving forces distinct from those underlying tropical pressures, remains an important gap in our understanding of how FSC certification affects forests globally.

We examine how FSC affects changes in boreal forests within the Far East region of the Russian Federation (Russia). Published work has yet to assess such dynamics using quantitative methods (though interested actors, for their own purposes, surely have been tracking such data over time). After documenting reduction in both forest and IFL over time within mapped forest concessions, we use regressions to compare unmatched, then matched, samples of FSC and non-FSC *kvartals* (smaller management units), controlling for other factors which might influence forest outcomes. Below we discuss, in turn, our methods and results − and then caveats which suggest extensions. Concerning both methods and results, given overviews just below we place details in appendices.

Methods

We consider the Far East region of Russia: Khabarovsk, Amur, Yevrey and Primorye subregions (see Figure 1 just below), a key area for forest production. Much conservation attention has gone to protecting large taiga forests, yet more heavily harvested temperate forests are more important for biodiversity (and only selective cutting of hardwoods is allowed in mixed temperate forests).

We considered '*kvartals*', the smallest administrative unit in our data with many per concession. For each, we examine forest change (annually), IFL (2000, 2013, 2016) and a variety of metrics linked to management such as taiga/tempate composition, elevation, slope, distance to road and rail networks as well as population centers, including city accessibility. After reconciling data on firm names, we limited our assessment of outcomes to when we had clear indications either of a certification (which started in 2012) or a non-certified lease (the earliest of which was in 2007). This higlights the issue of missing data, as we had to drop units without key management dates.

We then assessed the our two outcomes – forest and IFL reduction – as well as their correlation, then carried out regression analyses to to link them to management and kvartal characteristics. To compare more similar kvartals, we 'matched' samples of FSC and non-FSC kvartals, then conducted post-match regressions to examine the effect of FSC controlling for characteristics.

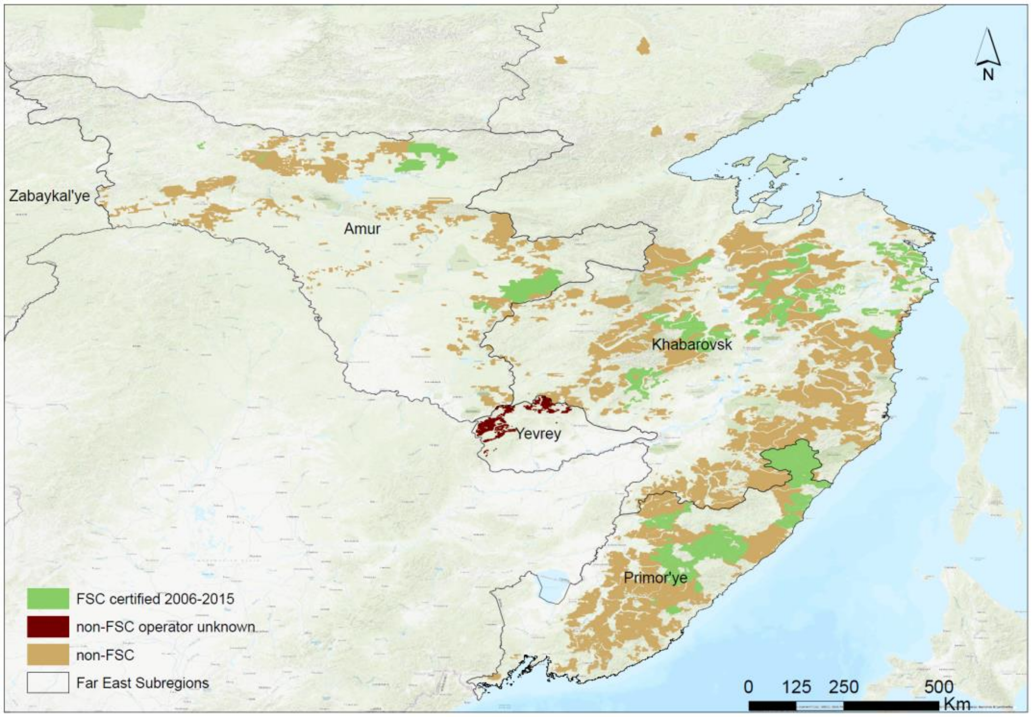

Fig. 1. Distribution of FSC and non-FSC concessions in the Russian Far East Region.

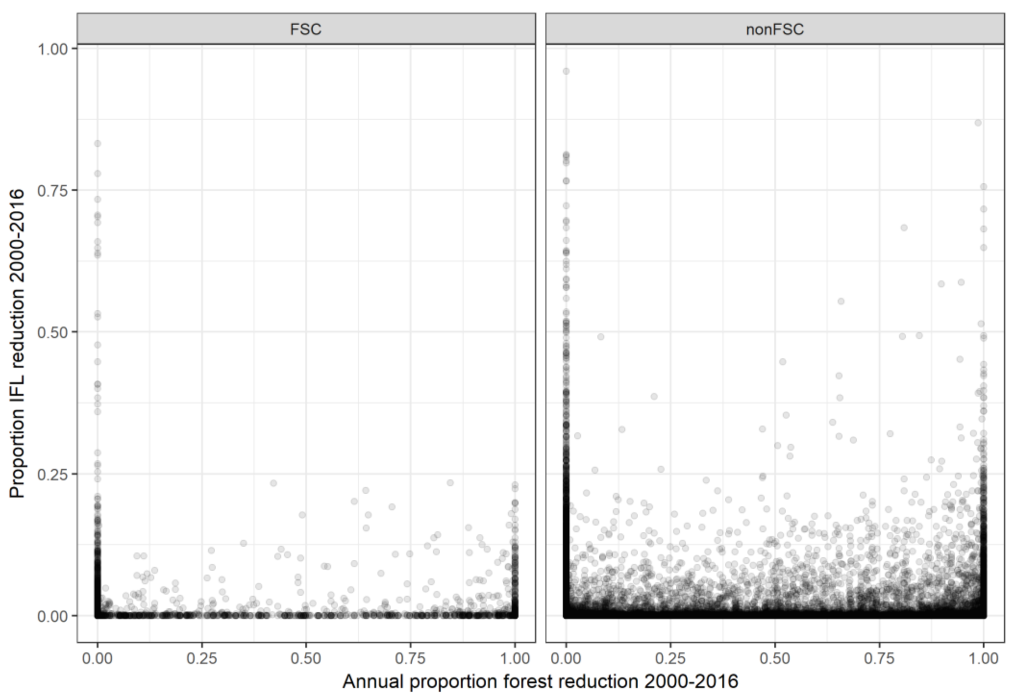

Fig. 2. Plot of two outcomes measures: annual forest reduction 2000-2016, cumulative IFL reduction 2000-2016. The outcomes do not have a linear relationship for FSC or Non-FSC managed kvartals in the Far East of Russia.

Results

To start, we show (as in Figure 2 just above) that IFL reductions are strikingly distinct from the patterns of forest reductions. There was no clear linear relationship between these two measures. There are instances no forest reduction but yet even 100% IFL reductions arising for 2000-2016. For either outcome, though, because logging is concentrated within concessions, most kvartals had little to no detectable forest or IFL reduction. We focus on the 10% with almost all change.

Among them, FSC and non-FSC kvartals had some differences in forest composition as well as distances relevant for transport costs, and thus to management, such as to roads, rails and cities. They also differ somewhat in terms of pre-FSC forest outcomes. We control for the differences (although this too highlights the limits on available data as we can control for what we observe).

Concerning FSC's possible impacts, FSC kvartals experienced slightly lower IFL reductions and the size of the estimated impact is fairly robust, although some controls eliminated significance. In contrast, FSC kvartals experienced slightly higher annual forest reductions, over this period and the size of the estimated impact is fairly robust yet we would prefer to have more controls.

Discussion

Management of forested kvartals within concessions, as either FSC or non-FSC, did not explain very well either forest or IFL reduction during 2013-2016. Explanatory power might rise with additional controls – spatial and temporal – that we were unable to include in this initial effort. Current controls have not shifted our initial FSC impact estimates much − yet others still might, and in addition inferences from the Far East region may not apply to the Central and Northwest. *Beyond our specific estimates of limited FSC impacts, our dominant theme was limits on data.*

Specifically, one key factor type to control further for could be characteristics of firms involved, such as the size and current activity (Brian Milakovsky, personal communication, May 3, 2018). Another feature of potential importance is which if any export markets are product destinations. Past activity might also be a useful indicator of 'type' to better match FSC and Non-FSC firms. Lacking management dates, though, it is possible different firms were managing the concession before our documented Non-FSC leases or FSC agreements. The past may not be very relevant. *All these factors (dates, firm characteristics and ownership, past activity) would be helpful data and in particular filling in lease/agreement dates could greatly improve comparisons over time.*

Also, the data on outcomes are subject to some limitations. The global forest-cover-change data (Hansen et al. 2013) may not capture smaller loss events, do not capture much forest degradation and do not distinguish anthropogenic (e.g., logging) versus natural causes (e.g., fire and pests). *If forest degradation per se is a central focus, costly effort to improve such metrics may be merited.*

Finally, our outcomes data do not include how forest changes affect biodiversity or ecoservices − for instance, areas with high IFL reductions may still contain sufficient intact forest patches to do a fine job providing value, e.g., in forested areas of headwater streams important to maintaining water quality. *It would be useful to know how distributions of forest and IFL reductions overlay plant and wildlife species distributions to understand the implications of FSC for biodiversity.*

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Appendix 1: Methods

Study Area: We consider the Far East region: Khabarovsk, Amur, Yevrey, Primorye subregions. The region is one of the most important forest production areas in Russia. Across forest regions, most timber resources in Russia are owned by the state, then can be leased to private companies (Elbakidze et al., 2013). This region has variable forest composition including mainly taiga forest – dominated by spruce, fir, larch, birch and Scots pine – and mixed temperate forest made up of Korean pine, spruce, fir, larch, oak, ash, elm, linden, birch, maple, walnut, cork tree and a variety of other tree species (Bartalev et al., 2004). While much conservation attention has been focused in the past upon various 'set asides', in order to protect the large remaining tracts of taiga forests, the temperate forests are more important from a biodiversity standpoint despite being historically harvested at higher intensities (Brian Milakovsky, personal communication, May 3, 2018). Clearcutting of hardwoods is prohibited in mixed temperate forests, although selective harvesting is permitted within these stands (Brian Milakovsky, personal communication, May 3, 2018).

Data Preparation

Spatial Units

We considered management at the scale of '*kvartals*', the smallest administrative forest unit in our data set. A concession typically contains many kvartals. To compare consistent observational units across management types and subregions, we joined the known FSC concession boundaries (FSC Russia, 2018a) and known non-FSC concession boundaries (WWF Russia, unpublished data) with kvartal borders for each subregion (FSC Russia, 2018b). Those concession shapefiles described not only the boundaries under each type of management but for most concessions also the FSC agreement number or lease number, the date the FSC agreement or lease was issued, and the name of the firm operating the concession. We conducted spatial joins using ArcGIS to link FSC and non-FSC attributes to kvartals, requiring that each kvartal's geographic centroid be within the boundary of a known FSC or non-FSC polygon to have the associated management attributes added to that kvartal. Our final complete dataset contains 34,421 distinct kvartals.

Forest & IFL Outcomes

For each kvartal, we documented both forest and IFL conditions over time. We calculated forest cover change from the Global Forest Cover Change Product (Hansen et al., 2013b) in Google Earth Engine's cloud-based analysis platform (Gorelick et al., 2017). We firstly, computed the baseline proportional forest cover in 2000 by tabulating the number of pixels within each kvartal with >0% canopy density and >50% canopy density, respectively. To estimate an upper limit of annual forest cover reduction for each kvartal for 2001-2016, we tabulated the number of pixels identified as "loss" relative to the extent of any forest cover (density >0%) mapped in 2000. IFL outcomes were tracked over time using ArcGIS (ESRI, 2014). We calculated the proportional coverage of IFL in each kvartal for all years of available data (2000, 2013, 2016; Potapov et al., 2017), and computed the proportional reduction over time relative to initial conditions in 2000.

Kvartal Characteristics

For each kvartal, we also computed a variety of additional metrics in Google Earth Engine, i.e., characteristics that might be associated with management. For example, stand composition may influence the volume and value of harvest, as well as the impact of harvest on biodiversity and ecosystem services. We added the coverage of temperate forest and taiga from a map of forest canopy density by forest type across Russia (Bartalev et al., 2004). Temperate forests in the Russian Far East tend to have higher biodiversity than taiga systems (Brian Milakovsky, personal communication, May 3, 2018). The original data was reclassified using temperate and broadleaf community types as the "temperate" forest community, with all others as the "taiga" community.

As terrain can influence accessibility and harvest strategy for a concession, we calculated both the average and the standard deviation of slope and elevation within each kvartal from a global elevation product (Jarvis, 2008). To assess whether proximity to transport networks mediated the effect of management on outcomes, we computed the average and standard deviation of distance to road and rail transportation networks (OpenStreetMap Contributors, 2018). We also calculated the mean and standard deviation of distance to population densities over 50 persons per hectare using the most recent density available (see Center For International Earth Science Information Network-CIESIN-Columbia University, 2016) as proximity to urban markets and labor supplies might affect management. We calculated the mean and standard deviation of city accessibility (Weiss et al., 2018), a resistance-surface based distance measurement which takes into account transportation networks and terrain, and may represent a more realistic measure of travel time.[1]

Compilation & Pre-processing

Additional manipulation was required before analysis to reconcile discrepancies between the diverse sources from which the data were collected. Fields containing Cyrillic characters were translated into English for easier analysis and interpretation. Outcome and control characteristics of each kvartal were combined into one master dataset using R, software which also was used for all our subsequent data manipulations and analyses (R Core Team, 2012). Slight discrepancies between firms' name identifiers across FSC and non-FSC concessions were reconciled using the lookup tables, in order to correctly track the operations of all the kvartals in the Far East region.

We limited our assessment of outcomes, during the period 2013-2016, to years that came after the issuance of a non-FSC lease or an FSC agreement for any given kvartal. We assumed that forest and IFL outcomes in the year(s) following the issuance of such a lease or FSC agreement could be attributed to management of that kvartal. While non-FSC leases were issued as early as 2007 for some of the kvartals in the dataset (Table 1), the earliest FSC certifications in the Far East that had never been invalidated or suspended were issued beginning in 2012. To assess the effect of FSC on outcomes, then, we used a subset of the full kvartal dataset (Table 1) retaining the best documented observations of FSC and of non-FSC management in the Far East region.

Kvartals that were lacking any date associated with FSC or non-FSC management in the data set were excluded from these analyses (13.5% of the original kvartal data). It seems inappropriate to attribute outcomes to kvartals' management without some known dates concerning management. We additionally dropped the kvartals that were linked to more than one firm or lease agreement.

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[1] Clearly more characteristics could matter (a theme in our Discussion below). For instance, we hoped to use data on the size and behavior of firms holding FSC and non-FSC leases, to improve comparisons' 'apples-to-apples' nature, and for some non-FSC lease agreements in the Khabarovsk and Primorye subregions information was available for the permitted and actual volume of clearcutting and of selective harvest activities (WWF Russia, unpublished data). However, at least to this point, our limited understanding prevented our use of those data even for this partial scope.

There were 3,067 kvartals in the dataset operated by 5 distinct firms that we consider as 'failed' FSC (i.e., for which at some point FSC leases were documented yet later, at some unknown date, they were suspended or invalidated). We dropped these kvartals from analysis as well, given that outcomes could not be associated with temporal changes in management status and management of these kvartals might not be consistent with either a clear FSC or a clear non-FSC management regime during the study period. This conservative filtering of the data set resulted in retention of 4,462 FSC kvartals (3 distinct firms, certifications issued 2012-2015; Table 1, row8) and 21,950 kvartals where FSC certification was never attempted (286 firms, with leases issued from 2007 onward; Table 1, row 2) – tracked over the years 2013-2016 (76.4% of the full kvartal dataset).

Analysis

Exploration & Regression

We started with exploratory examinations of how forest and IFL reduction outcomes played out across a range of kvartal characteristics. All control variables were centered by subtracting the arithmetic mean from all values for each variable. We assessed the relationship between the two outcomes themselves – forest reduction and IFL reduction – and for collinearity between many of the kvartal characteristics that might serve as controls for matching and predictors in models of the outcomes. As noted (and see Figure 1), we concluded that the outcomes are distinct and from assessing the collinearity of the possible controls we can use sets that are also distinct.

To link outcomes to management and kvartal characteristics we conducted a series of regressions examining forest reduction and IFL reduction outcomes, respectively, using the estimatr package (Blair, Cooper, Coppock, Humphreys, & Sonnet, 2018). To further consider ways of ensuring comparison of similar kvartals, we identified 'matched' samples of FSC and non-FSC kvartals using both multivariate matching and propensity score-based matching with balance optimization (Diamond & Sekhon, 2013) using the Matching package (Sekhon, 2011) – although we hasten to emphasize that trying to find the best possible similarity certainly would not guarantee similarity. Consequently, we also conducted post-match regressions in order to examine how controlling for kvartal characteristics mediated the effect of management on forest reduction and IFL outcomes.

Given that only a few firms successfully underwent FSC certification, treating each kvartal as a fully independent observation might not be appropriate. Thus, we additionally clustered standard errors by firm. We applied this statistical correction to first a standard linear regression including only FSC treatment as a predictor of reductions, and then to a regression with controls for years and other factors, and finally to the latter regression applies after matching (for each approach to matching – covariate and propensity score), and at the same incorporated robust standard errors.

Forest vs. IFL

Our initial assessments found that the spatial pattern of the cumulative IFL reductions during 2000-2016 was strikingly distinct from that of annual forest reductions tracked over the same period within kvartals in the Far East of Russia (Figure 2). There was no clear linear relationship between these two measures. There were many instances of FSC and non-FSC kvartals where no forest reduction was observed but, still, substantial IFL reductions had occurred from 2000-2016.

Appendix 2: Results

Concentrated Logging

Over the study period (2013-2016), a very clear majority of the kvartals experienced little to no detectable change in either forest cover or IFL, regardless of management (Table 3A, Table 3B). Within 60% of kvartals, < 0.1% annual forest reduction was observed, while < 2% annual forest reduction was observed within 80% of kvartals looking across all years (Table 3B). Similarly, 80% of kvartals experienced < 0.01% IFL reduction 2013-2016 (Table 3A). Only a small portion of kvartals contained significant forest and IFL reductions (<10% of kvartals for each), therefore we focus on kvartals in the 10th decile of reduction for both forest- and IFL-reduction outcomes.

Kvartal Differences (observed)

FSC and non-FSC kvartals were similar with respect to many of the quantitative characteristics that we measured, yet there were a few notable differences in terms of relatively fixed features. FSC kvartals tended to have lower temperate forest community zone cover (median = 0.029, mean = 0.278) as compared to non-FSC kvartals (median = 0.259, mean = 0.453). FSC kvartals were also further from cities according to city accessibility index values (median = 765.542, mean = 851.028) compared to non-FSC kvartals (median = 554.357, mean = 604.729). We are able to include all such observed characteristics in regressions, and as a basis for matching too, although we would hasten to point out that there are many differences that we do not observe (while differences across firms are clear even within simple plots, as in Fig. 3A.i, Fig. 3A.ii).

Another possible basis for considering similarity across kvartals is their past forest outcomes, as the past management behavior could well summarize the effective importance of key differences. However, as noted we are limited by knowledge about who controlled which kvartals in the past. Nonetheless we examined past forest outcomes for these kvartals, finding that a very large share of them had very little past change (i.e., change prior to the beginning of FSC certifications). We have done controls for past forest and IFL reductions within our regressions, though without the knowledge of who controlled those kvartals it seems inappropriate to use as an outcome measure the change in forest outcomes after FSC certifications versus the changes in the previous periods.

Estimated FSC Impacts

IFL Reduction

Both simpler regression results summarizing group differences and our regressions with controls revealed that FSC kvartals experienced slightly lower IFL reductions (~3% lower) in 2013-2016 as compared to non-FSC concessions (Tables 3A, 4A with roughly 10% versus 13% reductions). The size of the estimated impact is fairly robust, although some controls eliminated significance.

Forest Reduction

Both simpler regression results summarizing group differences and our regressions with controls revealed that FSC kvartals experienced slightly higher annual forest reductions, over this study period, as compared to the non-FSC (Tables 3B, 4B with roughly 1% higher annual reductions). The size of the estimated impact is fairly robust. Yet, as noted, we would prefer further controls.

TABLE 1.

Summary of the data set (using kvartal units), for the Far East region of Russia, by type and management status over two distinct periods: 2008-2012, 2013-2016.

	Type	Period	Status	# kvartals	# firms	# obs
1	never FSC	2008-2012	non-FSC	18210	264	65646
2	never FSC	2013-2016	non-FSC	21950	286	85899
2b	*never FSC*	*2013-2016*	*non-FSC*	*18210*	*264*	*72852*
3	failed FSC	2008-2012	non-FSC	2936	4	11283
4	failed FSC	2013-2016	non-FSC	2936	4	11744
5	failed FSC	2013-2016	unknown	131	3	444
6	clear FSC	2008-2012	non-FSC	3635	2	13343
7	clear FSC	2013-2016	non-FSC	2911	1	8733
8	clear FSC	2013-2016	FSC	4462	3	7464
8b	*clear FSC*	*2013-2016*	*FSC*	*3635*	*2*	*5807*

[1]Non-FSC operation 2008-2012, concession never certified.

[2]Non-FSC operation 2013-2016, concession never certified.

[2b]Non-FSC operation 2013-2016, concession never certified, including only kvartals common across periods.

[3]Non-FSC operation 2008-2012, attempted certification.

[4]Non-FSC operation 2013-2016, attempted certification.

[5]Unknown management (no documented lease as Non-FSC) 2013-2016, attempted certification.

[6]Non-FSC operation 2008-2012, became certified.

[7]Non-FSC operation 2013-2015, became certified.

[8]FSC operation 2013-2016.

[8b]FSC operation 2013-2016. Only includes kvartals common across periods.

TABLE 2A.

Balances for testing FSC impact on IFL, without matching and with each approach.

	Treated	All Controls	Propensity Matched	Covariate Matched
Area (ha)	51	145***	18	10***
Elevation	170	175	204**	230**
Slope	1.7	2.4**	2.8***	2.7***
Temperate Share	-0.151	-0.211***	-0.022***	-0.137**
City Access Index	532	104***	482***	431***
Road Distance (k)	323	195***	169***	309***
Rail Distance (k)	27	17***	37***	34***
Distance to Pop	723	-8311***	8825***	7974***
Treecover '00 Share	0.058	0.037***	0.039**	0.071***

TABLE 2B.

Balances for testing FSC impact on forest, without matching and with each approach.

	Treated	All Controls	Propensity Matched	Covariate Matched
Area (ha)	29.604	73.613***	5.717**	16.964**
Elevation	111.928	110.680	128.513	132.929***
Slope	0.162	1.041***	0.110	0.667***
Temperate Share	-0.220	-0.212	-0.230**	-0.199***
City Access Index	238.439	82.548***	224.586*	183.720***
Road Distance	55684.548	-58538.051***	52912.885	47259.010***
Rail Distance	5676.818	12169.750	8383.391	10307.143***
Distance to Pop	-5788.852	-3334.319**	-4252.995	-1239.751***
Treecover '00 Share	0.041	0.013***	0.040	0.053***

TABLE 3A.

Average proportion of IFL reduction 2013-2016 within kvartals in Russia's Far East region according to the decile of IFL reduction (each decile contains 10% of the kvartal data).

	Average IFL reduction by decile											FSC - NonFSC Difference	
Status	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**All Data**	**10th**	**All Data**
FSC	0	NA	NA	0	0	0	NA	NA	0	0.097	0.012	-0.036	-0.001
non-FSC	0	0	0	0	0	0	0	0	0	0.133	0.013		

TABLE 3B.

Average annual proportion of forest reduction within kvartals in Russia's Far East regon according to the decile of forest reduction (each decile contains 10% of the kvartal data).

	Average annual forest reduction by decile 2013											FSC - NonFSC Difference	
Status	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All Data**	**10th**	**All Data**
FSC	0	NA	NA	0	0	NA	NA	0.000	0.001	0.048	0.009	0.011	0.006
non-FSC	0	0	0	0	0	0	0	0.000	0.001	0.038	0.003		
	Average annual forest reduction by decile 2014											**FSC - NonFSC Difference**	
Status	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All Data**	**10th**	**All Data**
FSC	0	NA	NA	0	0	NA	NA	0.000	0.001	0.044	0.008	0.022	0.006
non-FSC	0	0	0	0	0	0	0	0.000	0.001	0.022	0.002		
	Average annual forest reduction by decile 2015											**FSC - NonFSC Difference**	
Status	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All Data**	**10th**	**All Data**
FSC	0	NA	NA	0	0	NA	NA	0.000	0.001	0.081	0.013	0.056	0.011
non-FSC	0	0	0	0	0	0	0	0.000	0.001	0.025	0.002		
	Average annual forest reduction by decile 2016											**FSC - NonFSC Difference**	
Status	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All Data**	**10th**	**All Data**
FSC	0	NA	NA	0	0	0	0	0.000	0.001	0.027	0.006	-0.001	0.002
non-FSC	0	0	0	0	0	0	0	0.000	0.001	0.028	0.004		
2013-16												**FSC - NonFSC Difference**	
Status	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**All Data**	**10th**	**All Data**
FSC	0	0	0	0	0	0	0	0.000	0.001	0.039	0.008	0.011	0.005
non-FSC	0	0	0	0	0	0	0	0.000	0.001	0.028	0.003		

n.b. The 2013-2016 data combine all the FSC observations across these years and all NonFSC observations. When a kvartal shifts to FSC status in 2016 – which applies to a number of kvartals – its values are counted in NonFSC for earlier years but FSC in 2016. Such shifts explain why the 2013-2016 average for FSC more reflects 2016.

TABLE 4A.

Regressions & Matching for IFL Reduction, 10th Decile Observations

	OLS	**Propensity Matching**	**Propensity & OLS**	**Covariate Matching**	**Covariate & OLS**
FSC	-0.0332 (0.0129)**	-0.0322 (0.0146)**	-0.0321 (0.0292)	-0.0216 (0.0140)	-0.0342 (0.0224)
Area			0.0018[1] (0.0219)		-0.0138[1] (0.0192)
Elevation			-0.0002 (0.0001)***		-0.0003 (0.0000)***
Slope			-0.0044 (0.0044)		-0.0059 (0.0028)**
Temperate Share			0.0232 (0.0760)		0.0095 (0.0680)
City Access			-0.0069[1] (0.0683)		0.0001 (0.0000)***
Road Distance			-0.0001[1] (0.0000)*		-0.0001[1] (0.00000)*
Rail Distance			-0.0003[1] (0.0001)***		-0.0002[1] (0.0001)***
Distance to Popul.			0.0021[1] (0.0009)**		0.0021[1] (0.0006)***
Treecover '00 Share			0.0849 (0.1162)		0.1824 (0.0342)***
Adj. R^2	0.0021		0.1405		0.1774
Clustered Std.Errors	no	no	yes	no	yes
FSC obs. Non-FSC obs.	635 2041	635 635	635 635	635 635	635 635

TABLE 4B.

Regressions & Matching for Forest Reduction, 10th Decile Observations

	OLS	Propensity Matching	Propensity & OLS	Covariate Matching	Covariate & OLS
FSC	0.0112 (0.0015)***	0.0118 (0.0023)***	0.0120 (0.0043)***	0.0157 (0.0025)***	0.0131 (0.0056)**
2014			-0.0141 (0.0042)***		-0.0106 (0.0037)***
2015			0.0036 (0.0116)		0.0069 (0.0143)
2016			-0.0094 (0.0053)*		-0.0079 (0.0065)
Area			-0.0073[1] (0.0062)		-0.0079[1] (0.0091)
Elevation			0.0065[1] (0.0055)		-0.0027[1] (0.0116)
Slope			-0.0006 (0.0000)**		-0.0008 (0.0003)***
Temperate Share			0.0223 (0.0073)***		0.0153 (0.0083)*
City Access Index			-0.0093[1] (0.0062)		0.0165[1] (0.0105)
Road Distance			-0.0002[3] (0.0003)		-0.0001[2] (0.0000)
Rail Distance			0.0004[3] (0.0013)		0.0004[4] (0.0124)
Popul. Distance			-0.0007[1] (0.0001)***		-0.0005[1] (0.0001)***
Treecover '00 Share			0.0073 (0.0157)		0.0113 (0.0198)
Adj. R^2	0.0055		0.1099		0.0871
Clustered Std.Errors	no	no	yes	no	yes
FSC obs. Non-FSC obs.	1474 7862	1474 1474	1474 1474	1474 1474	1474 1474

SUPPLEMENTARY MATERIALS

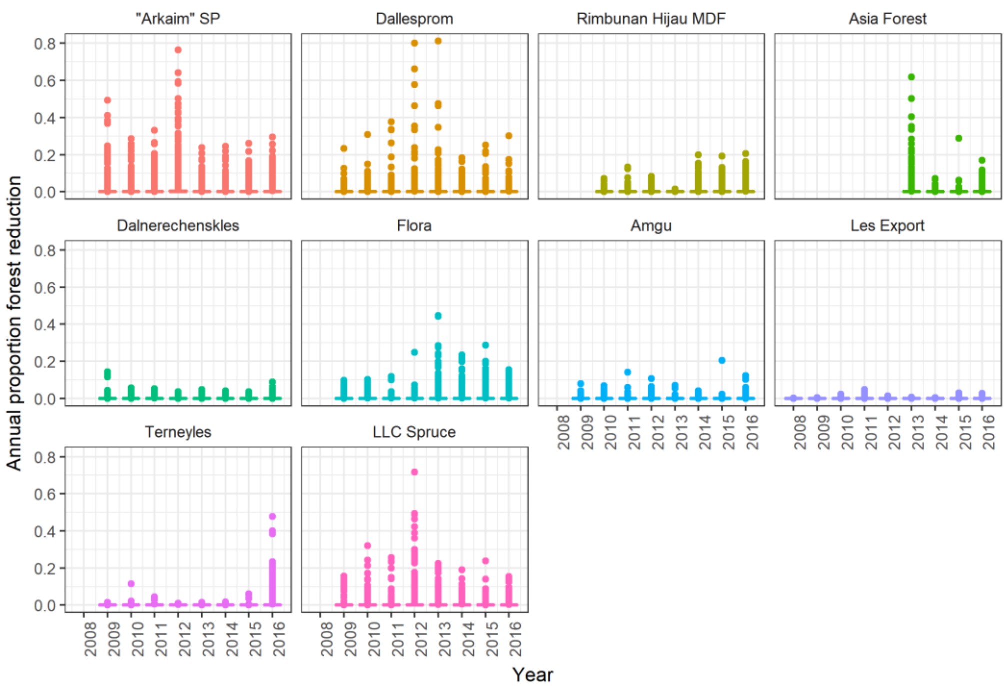

Fig. 3A.i. Annual rates of forest reduction across the top 10 firms in the Russian Far East ordered (Left to Right, Top to Bottom) by the total spatial extent of concessions operated by that firm.

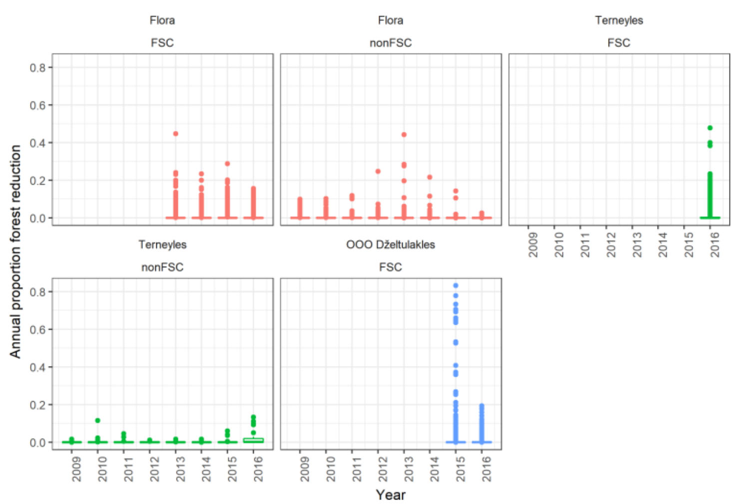

Fig. 3A.ii. Annual rates of forest reduction by firm within kvartals that were successfully certified in the Far East of Russia. In some cases, kvartals managed by Flora and Terneyles were under known non-FSC lease agreements in the years preceding certification. For certified kvartals managed by Dzeltulakles, no preceding non-FSC lease information was documented.