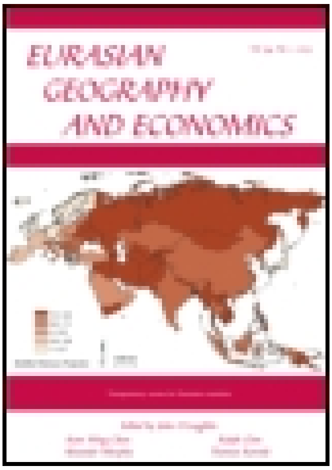

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Russia's forests in a global economy: how consumption drives environmental change

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Russia's forests in a global economy: how consumption drives environmental change

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The forests of Russia comprise roughly one-fifth of Earth's total forest cover and one-quarter of its remaining "frontier" forests. The *quality* (i.e. natural productivity) of these forests continues to decline, however, with timber harvest a major underlying cause. Efforts to ameliorate forest degradation have been *production* centric, with a focus on the infusion of technology to improve manufacturing capacity, revision of the Forest code for better forest governance, and strategies to control illegal logging. However, *consumption* also drives forest change. Using production and trade flow data from 1946 to 2012, this paper assesses the state of Russia's forest resources and demonstrates how sweeping changes ushered in by perestroika and globalization have forged a highly export-dependent forest sector. Once consumed internally (approx. 90% of total production), wood from Russia's forests is now a global resource – the country annually exports approximately two-thirds of its sawnwood production. In tracking these flows through China to US urban centers, with timber becoming furniture and flooring sold in big-box stores, we demonstrate how consumption patterns affect ecosystems and socioeconomic relations in resource and manufacturing peripheries far beyond regional and national borders. The "ecological shadow" of forest change and degradation in post-Soviet Russia, therefore, is a confluence of factors related to both consumption and production: globalized shifting external market demand; the spatial fracturing of the industry; inefficient production; internal corruption; and weak forest governance. The Russian forest case provides evidence that we need to approach complex environmental (and development) issues as a coupled production–consumption dynamic. More broadly, the research is illustrative of how Russia has become embedded within the global economy through a constellation of resource flow linkages and networks.

Keywords: Russia; China; land use change; resource consumption; forests; illegal logging; environment; governance; material flow analysis; region

Introduction

The forests of the Russia Federation present a fascinating and important study of the intertwined complexities of land cover and land use change, globalization, industry restructuring, shifting capital flows, and post-Soviet transition. Russia has more forests than any other nation, representing approximately 22% of the world's total forest cover, more than half of the world's coniferous forests, and one-quarter of the remaining

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"frontier" or "old-growth" forests (Potapov et al. 2008). In economic terms, these forests represent about 21% of the world's standing timber volume, and they sequester more carbon than those found in any other nation (Houghton et al. 2007). By all accounts, they are a global treasure, crucial for mitigating climate change, for conserving biological diversity, and for supporting the thousands of communities throughout Russia who rely on the natural resources they provide.

What is less well known about Russia's forests is that more than half grow on permafrost – frozen ground that thaws and freezes as part of the climate cycle. Vast tracts of the *taiga*, the large mass of boreal forest that extends across broad latitudes of Russia, are unsuitable for commercial harvest.[1] In Siberia and the Russian Far East (RFE), larch forests predominate; some stands are commercially valuable, but others are too spindly or are inaccessible due to lack of infrastructure. Along the floodplains, where the larch tends to grow more quickly and reaches larger diameters, poplars (*Populus* sp.) and willows (*Salix* sp.) are interspersed. Moving north, the great *taiga* transitions into tundra, where dwarf Japanese stone pine (*Pinus pumila*) and Dahurian larch (*Larix gmelinii*) grow in unusual horizontal formations, stunted by the wind, shallow soil, and cold, dry climate. In parts of European Russia and along the more southerly belts of Siberia and the RFE, forest composition gradually becomes more complex, with spruces (*Picea obovata, P. ajanensis*), firs (*Abies* sp.), and pines (*Pinus* sp.), although tundra can still be found far to the south along the mountain ranges.

At first glance, the health of Russia's forests appears to be remarkably intact. National forest inventory data (FAO 2012) indicate that the area (in hectares [ha]) of total forest land and forest cover, as well as growing stock (in cubic meters [m^3]), has actually increased over the past 50 years (1956–2010). But these same inventory data also reveal a continued decline in forest *quality*. In Russia, the natural productivity of the growing stock (m^3 per ha) and the age of the forest stands has decreased continuously (Figure 1). For this reason, forest change is better measured in terms of change in forest stock (e.g. biomass, carbon) rather than overall forest cover (Kastner, Erb, and Nonhebel 2011).

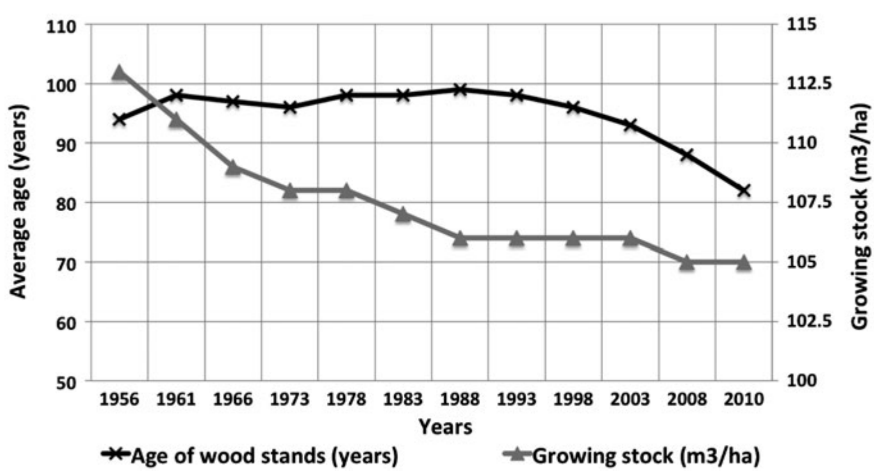

Figure 1. Growing stock, by volume (m^3 per ha) and age (years).
Source: FAO (2012).

In ecological terms, natural productivity can be measured as the degree of "intactness." Aksenov et al. (2002) used remote sensing to quantify changes in Russia's intact or frontier forests, documenting a loss of 16% (355 million ha to 297 million ha) from 1997 to 2005. Russia's frontier forests (Figure 2) are located primarily in Eastern Siberia (39% of the total), the Russian Far East (38 perecent), and European Russia (9%). According to the 2010 Russian Federation Forest Resource Assessment, "primary forests" represent approximately 22% of the total forest area, with other naturally regenerating forests totaling 66% and plantations, approximately 2% (FAO 2010). Broadly speaking, Russia's northern forests are less fragmented than the heavily roaded forests in the south, which are also more commercially valuable (for their larger trees, more variety of species, and denser forests). Scholars attribute the actual expansion in forest cover to increased growth on denuded and former agricultural lands (Baumann et al. 2011).

The forest succession underway in Russia is the unabated transformation of mature coniferous forests (spruces, pines, firs, and larch) into younger, less commercially valuable deciduous forests (aspen, birch, etc.). This loss of forest *quality* is the result of a confluence of anthropogenic disturbances (e.g. forestry, mining, road construction, oil and gas development, and clearing for agriculture) and natural ones (e.g. pest outbreaks and fire). Timber harvest and forest fire are the two types of disturbances most frequently cited for the loss of forest quality in the country as a whole (Cushman and Wallin 2000; Achard et al. 2006). Although fire can be a natural disturbance regime, in many cases it is triggered by human activity. For example, studies of incidences of fire in the Russian Far East from 1740 to 1990 indicate that most fires in fact were human

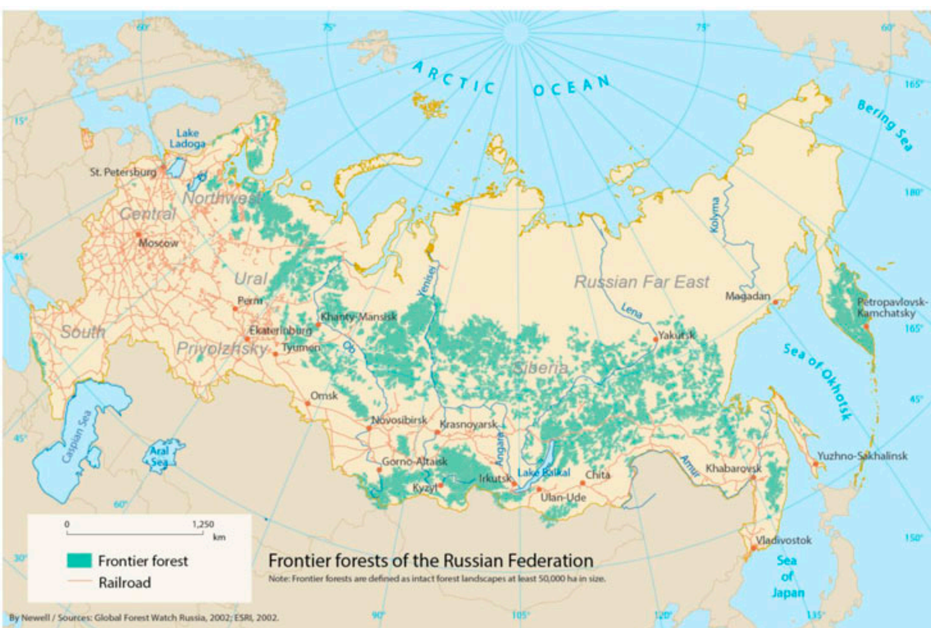

Figure 2. Frontier forests of the Russian Federation.
Source: Newell, 2004. Reprinted with permission.

induced, with a primary fuel source being the desiccated logging residue left at the harvest site (Sheshukov, Savchenko, and Peshukov 1992; Sheingauz 1996).

Drivers of forest degradation in Russia

How can we understand forest degradation in Russia, therefore, without first understanding the sector that drives this environmental change? This paper focuses on the Russian forest sector, from the late Soviet period to the present, and differs from traditional *production*-centric interpretations of environmental change in Russia in that we are attentive to both *production* and *consumption*. *Production* refers to the output of the sector, including the make-up of wood products (such as roundwood, sawnwood, pulp and paper, and panels) and geographic shifts in this production. We also refer to regulation and governance of this industry, including how perestroika reshaped the country's forest management institutions. By *consumption*, we refer to the flows of these products, their uses, and their governance.

Drawing on basic principles of a methodology known as material flow analysis (MFA) and using a range of production and trade data-sets dating back to 1942, this paper provides a basic accounting of Russian timber flows over space and time. Specifically, we quantify production and bilateral trade flows of Russian wood products, with a particular focus on the wood supply chain to China, Russia's largest wood export market. This MFA reveals the transformation of an industry that was geared primarily toward satisfying internal Soviet demand to one that is highly export dependent; the result is a structural adjustment reflective of broader transformations of the once-isolated, independent structure of the Soviet-era economy. As such, development and market forces, indeed *consumption* drivers, outside its borders, influence the patterns and processes of resource use throughout the Russian Federation.

We conclude that forest degradation in Russia is the result of a complex confluence of production–consumption dynamics: the influences of export demand for specific timber species, inefficient production processes, internal corruption, and weak forest governance. The causes, patterns, and spatial locations of this degradation differ significantly from that of the Soviet period. For example, the primary driver is not overall harvest levels per se, but rather the intensive, often unregulated harvest of timber species that are in high demand on export markets. Intensive harvest appears to be concentrated in regions that are in close proximity to these markets. This is the case in the Sikhote-Alin' region of the southern Russian Far East, where the demand for oak and ash timber in the Chinese-manufacturing industry is leading to unsustainable (and often illegal) harvest practices. Based on an analysis of where these Chinese products are ultimately consumed, the "ecological shadow" of Russian forest degradation extends beyond China to major end-consumer countries, such as the United States, Western Europe, and Japan.

Our attentiveness to production–consumption dynamics is reflective of a growing body of scholarship investigating the wide-range effects of trade and consumption land use transitions and forest change (Foley 2005; Meyfroidt and Lambin 2009; Pfaff and Walker 2010; Rudel et al. 2005), as globally the ratio of traded forest products to production has increased continuously, from about 12% in the 1960s to 35% in 2007 (Kastner, Erb, and Nonhebel 2011). In addition to exporting timber, Russia is the world's largest provider of natural resources, with its other extractive industries (e.g. oil and gas, mining) integrated into international markets (WTO 2010). This necessitates research in environmental and development issues beyond Russia's borders to the constellations of supply chains and networks that intertwine it with the global capitalist economy. This is a conceptualization of "region" that recognizes a territory's interdependence, as it is continually shaped and reshaped by processes of globalization, nation–state dynamics, and resource availability and demand.

The structure of this paper is as follows. The next section provides a critique of production-centric Soviet and post-Soviet environmental research and a theoretical and methodological background on the production–consumption approach. "The shifting geography of Soviet and Russian timber production and trade" section uses timber production and trade data, field research, and relevant studies to characterize the changing structure of the timber industry and forest management, including the effects of privatization, trade liberalization, and institutional corruption. The "Discussion and conclusion" section reflects on the sector as an underlying cause of forest change. To more deeply explore linkages between forest quality, governance, illegal logging, and timber production and consumption patterns, we include a case study of forestry in the Sikhote-Alin' Mountains. The paper concludes by identifying areas for future research, including strategies for strengthening forest governance at local, federal, and international levels.

Production–consumption dynamics and environmental change

> When production creates problems such as pollution, the productive answer is to produce correctives such as scrubbers, filters, and detoxifiers. So goes the logic of production, productiveness, productivity, and products – construing all things economic as producing, as adding value, as indeed, progress. The "consumption angle" turns this around to self-consciously construe economic activity as consuming, as depleting value [natural capital], as risking ecological overshoot, as stressing social capacity. (Princen, Maniates, and Conca 2002, 25–26).

Traditionally, underlying causes of environmental stress and degradation in the Russian Federation have been attributed to problems and inefficiencies associated with *production*. This is reflective of broader scholarly research on the environment of the Russian Federation, which has been largely conducted from within the perspective of the single nation-state, whereby causes (and proposed regulatory responses to) environmental degradation tend to originate from within a rather sharply delineated sense of "region" (Bityukova and Argenbright 2002; Henry and Douhovnikoff 2008; Trumbull and Bodrov 2009; ZumBrunnen and Trumbull 2003; Wendland et al. 2011).[2] In this theorization, places (regions) tend to be treated as discrete and self-contained, without often considering how other territories, places, scales, and networks help shape (and are shaped by) the production of that particular space. This can become an analytical trap (Jessop, Brenner and Jones 2008), where a part (e.g. territory, place) is conflated with the whole (e.g. totality of social spatial organization). "Region" can become reified as rigid, atomistic, and self-determining, even though a growing chorus of scholars reminds us that regional formations are often porous, partial, and continually reconstituted (Cartier 2002; Murphy and O'Loughlin 2009; Pred 1984; Thrift 1994).

Place-centric, production-based approaches to environmental research have strong roots in Soviet-era scholarship (Barr and Braden 1988; Feshbach and Friendly 1992; Pryde 1991; ZumBrunnen, Osleeb, and Morrow-Jones 1979; ZumBrunnen and Osleeb 1986). Transition-era studies largely continued this research legacy and were highly skewed toward issues of inefficient (or misguided) production and the subsequent pollution of the air, water, and land and wanton use of resources (Feshbach 1995;

Peterson and Bielke 2002; Peterson 1995; Pryde 1997, 1999). A contemporary example of this state-centric, *production*-focused scholarship is Henry and Douhovnikoff's (2008) review of current key Russian environment research themes: the rise and decline of state environmental protection; the relationship between post-Soviet economic transition and environmental quality; water quality; radiation; and the emergence of a civil society.

The *consumption angle* analytically shifts focus from environmental "improvements" (due to more efficient production processes and better regulatory practices) toward the explicit analysis of consumption and its externalities (Princen, Maniates, and Conca 2002). This recentering of consumption as a fundamental driver of environmental change is rooted in the idea of "ecological" limits, essentially that we exist in a state of ecological overshoot that is draining our precious natural capital, leading to a range of environmental crises from irreversible species loss to climate change. Perhaps most vividly represented as the ecological footprint (Wackernagel and Rees 1996), this *angle* seeks to make transparent consumption's scale and scope, with the normative claim that high-consuming nations, regions, cities, and consumers share responsibility for environmental and social impacts.

A challenge is to frame understanding of environmental change as a complex production–consumption dynamic, which elucidates their relative importance without privileging, to the extent possible, one over the other. Ecological footprint studies quantify resource consumption and broadly assign responsibility for ecological overshoot, but rarely focus on the production processes nor do they explicate why and how resource inequality occurs within and between nations and regions and their respective human populations. Geographers have long documented this phenomenon as uneven development (Smith 1990). An early approach to conceptualize drivers, patterns, and processes of uneven development was through core–periphery theory, whereby the core produces and consumes manufactured goods and the periphery is the source of raw materials and foodstuffs. Since then, political ecologists have used a range of largely political economy approaches to unveil inequitable social and ecological relations at an ever-growing array of geographic locations and contexts (Hecht 1985; Peet and Watts 1996; Robbins 2004; Zimmerer and Bassett 2003).

In the global environmental politics literature, scholars invoke the metaphor "ecological shadow" to essentially ground the resource consumption dimensions of core–periphery theory, although rarely from a Marxist perspective. Ecological shadows attempt to incorporate how trade, development finance, and government subsidy (and other aspects of the political economy) shape and sustain core–resource periphery consumption patterns (MacNeil, Winsemius, and Yakushiji 1991). Dauvergne (1997) added intellectual rigor to the metaphor by focusing on the shadow of a geographically embedded commodity chain (Japanese consumption of South East Asian tropical timber) to illustrate how, over time space, ecological shadows emerge from a complex interplay of government policy, corporate practice, and consumer demand.[3]

Similarly, Gellert (2010) analyzed how markets have shaped regional governance of Asian timber production. In this theorization, the import and transformation of natural capital, often drawn from thousands of miles away, forms the "shadow ecology" of a particular economy. At one spatial scale, impacts may be localized, but over the long term at the global scale, the ecological shadows of the world economy threaten all in the form of climate change, species extinction, and natural resource depletion. As with the footprint literature, by externalizing environmental costs, the underlying normative claim is the ecological debt that consuming cores have to nations and regions serving as resource peripheries.

In economic geography, a recent influential attempt to understand the complexities of the global economy is through the global production network (GPN) framework, which emerged largely as a geographical response to address what were seen as structural limitations of global commodity chain analysis (Gereffi and Korzeniewicz 1994). A GPN has been defined as "a nexus of interconnected functions, operations, and transactions through which a specific product or service is produced, distributed, and consumed" (Coe, Dicken, and Hess 2008). GPNs are interconnected through a series of links and nodes that extend spatially across national boundaries. Although they are inherently dynamic, continually reshaped organizationally and geographically, many GPNs illustrate a certain durability or *embeddedness*, which Hess (2004) divides into social, network, and territorial embeddedness. Above all, a GPN is a heuristic framework emphasizing a relational view of global development and process, and it recognizes the complexities among a broad kaleidoscope of actors, including institutions, firms, NGOs, and others.

The extractive industries, of which we include the timber sector, have received less attention in the GPN literature (Bridge 2008). This is reflective of a general gap in the literature in terms of connecting processes of production, distribution, and consumption to the natural environment in which they are fundamentally grounded (Hudson 2001). As such, GPN research has neglected the ecological dimensions of consumption by thinking about production simply as value creation rather than as a "process of materials transformation in which environmental change and the organization/disorganization of matter and energy are integral rather than incidental to economic activity" (Bridge 2008, 77). As noted by GPN scholars, an approach that holds particular promise in reconnecting processes to the environment is by conceiving of production–consumption chains/networks as *a system of material flows and balances* (Coe, Dicken, and Hess 2008; Turner, Pearce, and Bateman 1994). By systematically tracking these flows and balances, one can begin to elucidate environmental changes at phases, points, and locations along the production–consumption processes for the various global production networks. Numerous methods can be used to explore this production–consumption nexus, including global commodity chain analysis (Gereffi and Korzeniewicz 1994), value chain analysis (Humphrey and Schmitz 2002), and actor-network theory (Goodman 2002). In the industrial ecology field, common mass balance approaches include MFA, life cycle analysis (LCA), input–output analysis, and industrial symbiosis (Graedel and Allenby 2003).

Theoretical contribution and methodological approach

In this paper, we draw on these literatures to inform our production–consumption analysis of Russian timber. Although we do not conduct a complete accounting of the timber flows and balances, we do adhere roughly to the basic principles of MFA, which is a method to quantify the flow of materials or resources, in terms of mass, within a defined geographic area or industrial sector over a set period of time (Brunner and Rechberger 2004; Fischer-Kowalski and Huttler 1999). MFAs track the flows of materials (or resources) through parts or all of their life cycles: from extraction, to production, transformation, consumption, recycling, and disposal of materials. In this paper, we conduct a partial MFA to map timber flows in the Soviet Union and Russian Federation from 1961 to 2012 by analyzing the production of roundwood, sawnwood, panel, and paper and paperboard. Specifically, we track the ratios of export and import of these products to domestic production. Similarly, for this same time period, we track bilateral export flows, by specific products (roundwood and sawnwood) for 1997–2012.

Since China has emerged as by far the largest export flow of Russian production, we also track production–import–export ratios by the same product categories dating back to 1962 and the major destinations (by country) of China's highest value wood products, which include furniture, plywood, and veneer panels. This allows for a rough accounting of the flows of Russian wood to China and the resulting consumption of Chinese wooden products in US, European, and other industrialized markets. Data-set sources include International Institute for Applied Systems Analysis (2007), UN FAO (2013), the Russian Federation's Federal Statistics Division (2013), the Forest Products Trade Flow Database of the European Forest Institute (2009), and the Global Trade Atlas (2013).

To *contextualize* the flow analysis, we incorporate concepts such as the production vs. consumption angle, the ecological shadow spatial metaphor, and global production networks. In this contextualization of post-Soviet forest sector change, we consider the role of selected actors in the production–consumption network, but full analysis is beyond this paper's scope. We are attentive to the role of the state, for example, which is influential at all administrative levels in Russia and in China, where the federal government's restrictions on domestic production and subsidies for import of roundwood have shifted timber harvest to Russian forests.

In reference to the term *degradation*, we use the definition by Johnson and Lewis (1995, 2): "the substantial decrease in either or both of an area's productivity or usefulness due to human interference." Robbins (2004) helpfully identifies four useful criteria to measure this degradation: (1) loss of natural productivity, (2) loss of biodiversity, (3) loss of usefulness, and (4) creation or shift in risk ecology. This paper focuses on natural productivity, with some attention to loss of biodiversity in the Sikhote-Alin' forest case study. In terms of identifying and understanding causes of this degradation, the political ecology approach outlined by Robbins (2004) is especially useful. Published research sources (Russian and English) include journal articles, government reports, fieldwork by NGOs (which in Russia is often done in collaboration with government enforcement and regulatory agencies), and theses and dissertation fieldwork (Newell 2002, 2008; Simeone 2013b, 2013c).

The shifting geography of Soviet and Russian timber production and trade

Historically, the dictates from the heads of the tsarist Russian state directed forest sector management throughout the Russian Empire. And prior to 1917, Tsarist Russia had periods when timber exports indeed played a significant role. By the early eighteenth century, British companies were logging in Arkhangel'sk and in Belorussia, and evidently these operations were so rapacious, the tsar himself had to intervene (Williams 2006). Completion of railways to ports along the Baltic and Black Seas opened up international markets to Russian timber, so by 1908, about 3 million m^3 logs were exported annually, primarily to Britain and Germany (Williams 2006).

During the Soviet period, however, exports retracted as the structure of the Soviet economy focused on building internal self-sufficiency. Central planners and state organizations dealt with all aspects of the forest sector, including timber destined for foreign markets through Eksportles, the state-run organization responsible for trade with countries outside the Soviet Union. Beginning in the 1930s (with Stalinist industrialization), rather than solely in regional pockets, the impacts on forests from logging were first felt across the Soviet Union, from the conifer–broadleaved forests of Primorsky Kray to the boreal *taiga* of Karelia. By the end of World War II, large-scale forestry operations had expanded greatly and, as with other industrial sectors, Soviet planners had entire towns and villages constructed in heavily forested regions to harvest and process timber resources (Newell and Wilson 1996).

By the 1950s, the Soviet Union had well-established, large-scale timber production facilities, especially in what are now the Northwestern, Siberia, and the Volga federal districts (*federal'nyy okrug)*, three of the seven federal districts or supra-regions that currently divide the Russian Federation (Figure 3). By the early 1970s, Soviet commercial industrial roundwood (log) and sawnwood (lumber) production had reached an annual production of more than 300 million m^3 and 120 million m^3, respectively, and production remained at or near those levels until Gorbachev's *Perestroika* in the mid- to late 1980s (Figure 4). Over the 1961–1989 time period, enterprises produced more value-added products, including a sharp rise in panels (fiberboard, particleboard, plywood, and veneer, 657% increase) and paper and paperboard production (211% increase).

By the late-Soviet period, central planning, subsidies, and state control had developed a timber sector whose production was designed to meet internal demand within the Soviet Union. Between 1964 and 1992, 90–95% of annual Soviet timber and pulp and paper production was consumed internally (about two-thirds in current-day Russian Federation and one-third in other regions of the USSR). There was no single year in which the percentage of forest products exported reached higher than 11% of total production (Figure 4). As with other industrialized sectors of the centralized Soviet

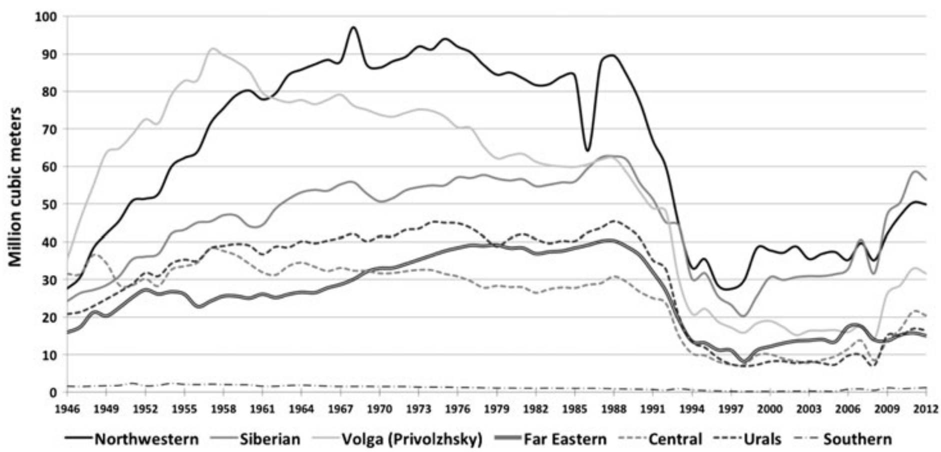

Figure 3. Timber production of the USSR and Russian Federation, by major federal district (*federal'nyy okrug*), 1946–2012.
Note: All data from 1993 onward are cited as data from Rosleskhoz (Russian Federal Forest Service) and denote total harvested wood by final commercial felling, whereas USSR data (1946–1992) also include intermediate harvesting. Therefore, post-1992 data in figure is an underestimate of total harvest volumes.
Source: Compiled by the authors based on data from IIASA (2007) and Russian Federation Federal Statistics Division (2013), including the FIRA database (2013) and EMISS database (2013).

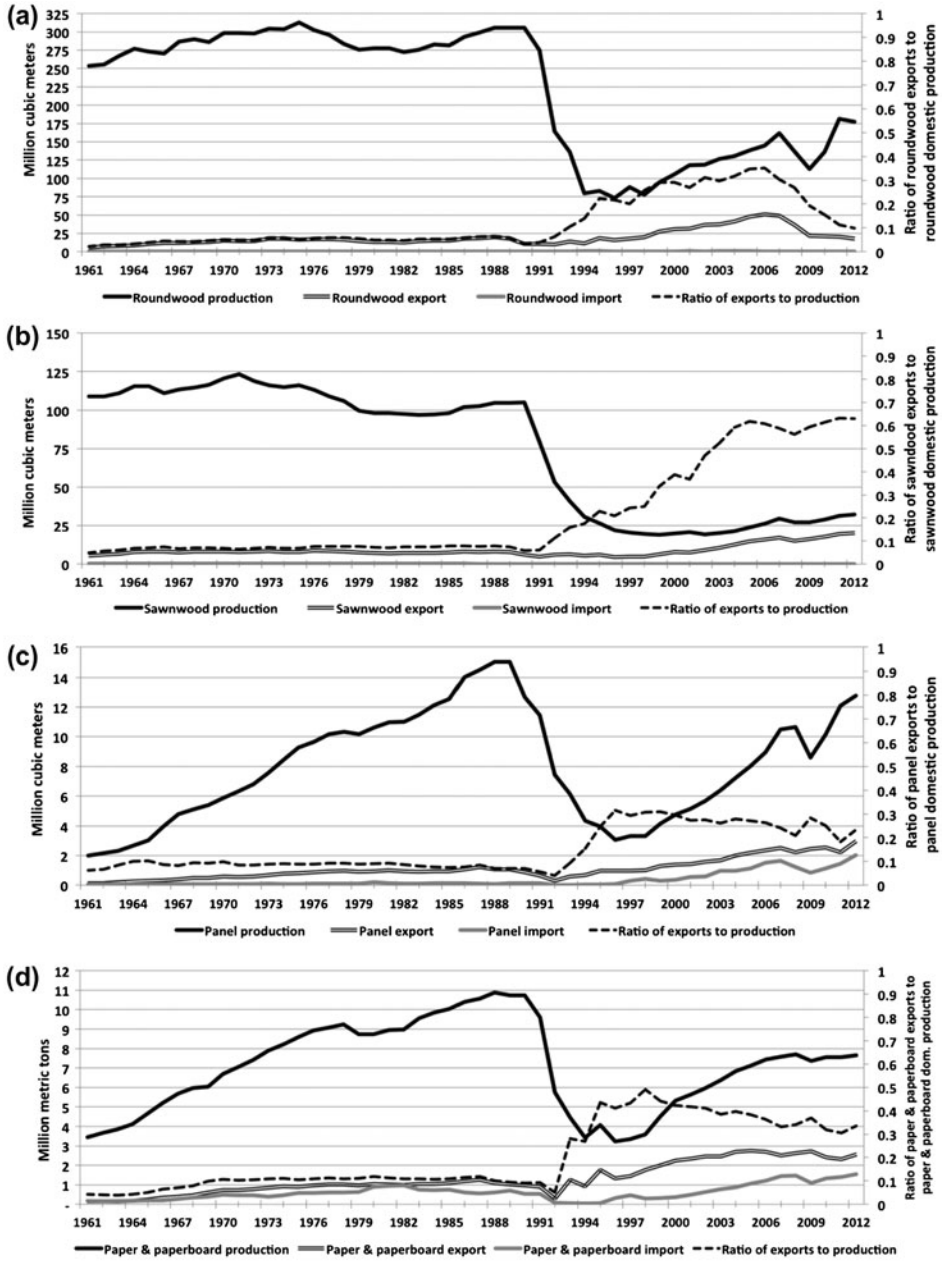

Figure 4. Production, export, and import of forest products from the USSR and Russia, 1961–2012 split by forest products: (a) roundwood; (b) sawnwood; (c) wood-based panels (includes fiberboard, particleboard, plywood, and veneer); (d) paper and paperboard.
Note: All production data represent total harvest wood by commercial harvest.
Source: UN FAO (2013).

economy, along with meeting domestic demand, regional timber industry conglomerates and forestry officials prioritized meeting annual and five-year production targets. This led to well-documented inefficiencies, high levels of waste, and an artificially high level of domestic consumption (Barr and Braden 1988). Although the influence of export markets, as well as concomitant demands for species wood species and products, was relatively limited, there is evidence of impact. In the 1980s, in response to Japanese demand, the Soviet government imposed harvest restrictions on Korean pine (*Pinus koreansis*), whose growing range is limited to a small portion of southeastern Russia (Sikhote-Alin' mountain range primarily). The selective overharvest would foreshadow forest degradation of the post-Soviet era in this region.

The 1990s: A time of forest sector transition

The post-Soviet transition led to fundamental and widespread changes in how the country's forests were harvested and managed, including rapid and radical privatization of the industry, abolishment of export controls, and repeated attempts to devolve forest management to Russia's administrative regions. In concert with processes of globalization and emergence of consumer markets for Russia's timber, this domestic restructuring has fundamentally reshaped the industry and, thus, its corresponding effects on Russia's forest cover and land use patterns.

As the Soviet Union collapsed, subsidies from the central government were sharply curtailed, including for the important transportation sector, and investments in wood-processing machinery and other infrastructure investments dried up (Thornton and Ziegler 2002). In the early post-collapse years, one scholar estimated the sector's output would not "even cover the cost of purchased raw materials alone, even if existing labor and capital prices were zero" (Thornton 2011, 14) and, without a drastic shift in technology and increased efficiency, the sector would remain uncompetitive.

As a result, the 1990s were a period of sharp production decreases, including of roundwood (up to a 40% decrease) and an even more dramatic decline for sawnwood and other value-added products (Backman 1998) (Figure 4). In addition to the outdated technology and lack of investment, outmigration was an exacerbating factor, and it was especially profound in both Siberia (7.4% loss from 1990 to 2009) and the Russian Far East (20% during the same period) (Thornton 2011), as depopulation of timber towns and transport hubs led to forest sector labor shortages.

Privatization of the state-owned harvest companies (*lespromkhozy*) that formed the core of the Ministry of Forest Products Industry (Minlesprom) and the ability to create new corporate entities spawned thousands of small and medium-sized timber companies throughout the 1990s. This trend was most prevalent in the Russian Far East and Siberia. For example, in 1991, just prior to the significant economic restructuring and administrative reform, there were only 82 *lespromkhozy*, 14 sawmills, and 10 pulp and paper plants operating in the entire Russian Far East (Sheingauz 2003). By 1995, 316 timber companies were officially registered in Khabarovsky Kray alone. By 2001, this figure had mushroomed to 550 (Sheingauz 2003). The division of Minlesprom responsible for strict control of timber export, setting prices, and regulating supply was also abolished, freeing up these companies to export their timber to the North-East Asian markets. In 1998, approximately 700 entities were registered as exporters to China. By 2002 that number of exporters had increased to more than 2300 (Lankin 2005).

An export-oriented industry emerges

The lure of hard currency was a catalyst for these newly formed harvest and export companies, and it accelerated the pace of export dependence of the post-Soviet forest sector. In 1991, just 3% of roundwood production was exported; by 1995, this figure was 22%, and by 2006, it reached 36% of total production (Figure 4). This export dependence was even more dramatic for sawnwood, increasing from 6% of the total in 1991 to 61% by 2006 (Figure 4), with a similar shift in the case of panels and paper and paperboard. Devaluation of the Russian ruble following the 1998 Asian financial crisis helped to enhance the competitiveness of Russia's exports (Thornton 2011). Ironically perhaps, the demand for value-added forest products within Russia itself has risen, but this has largely been supplied by imports rather than domestically produced products (Figure 4(c, d).

This restructuring led to emergence of Russia as a global leader in roundwood exports (Robbins and Perez-Garcia 2012; Simeone 2012; Simeone 2013a; Sun 2014). By 2007, Russian log exports comprised almost one-third of the world's total, rising from approximately 22% in 2001. For over 20 years, virtually all of Russia's roundwood has been exported to just five countries – China, Finland, Japan, South Korea, and Sweden – with China being by far the largest market (Figure 5). Russia became especially dominant in export of softwood logs; primarily pine, fir, and spruce. In 2006, for example, 92% of China's total softwood log imports came from Russia, 75% of Finland's, 39% of Japan's, and 24% of South Korea's.

To capture more value-added production, in 2007, the Russian government instituted scaling export tariffs on roundwood and sizeable subsidies for investments in the wood-processing infrastructure.[4] The tariffs had an almost immediate effect, especially to China, in favor of more sawnwood and less roundwood (Figure 6). But they have not translated into deep value-added processing; rather, just enough to avoid the export tariff. In addition, Russia joined the WTO in 2012, and as a precondition for inclusion,

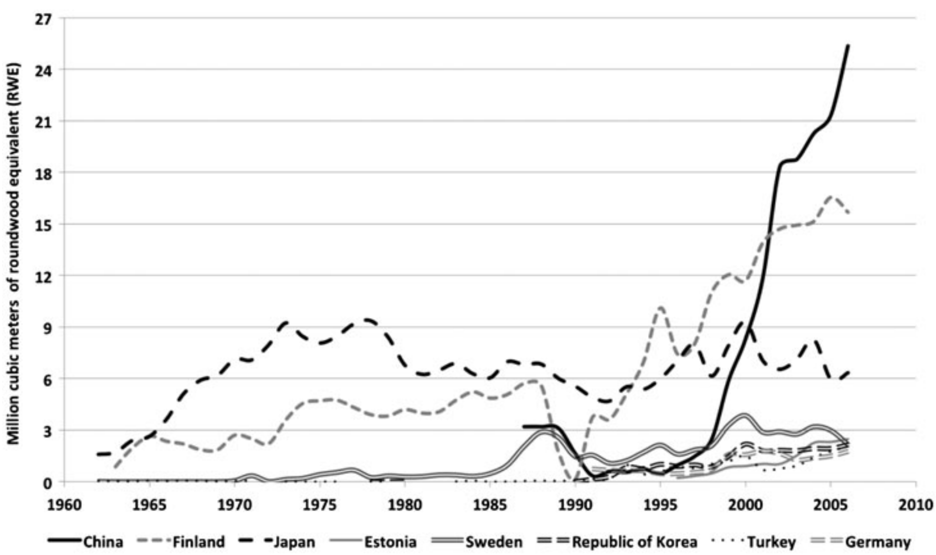

Figure 5. Major export markets for Russian forest products, 1962–2006.
Source: Forest Products Trade Flow Database of the European Forest Institute (2009).

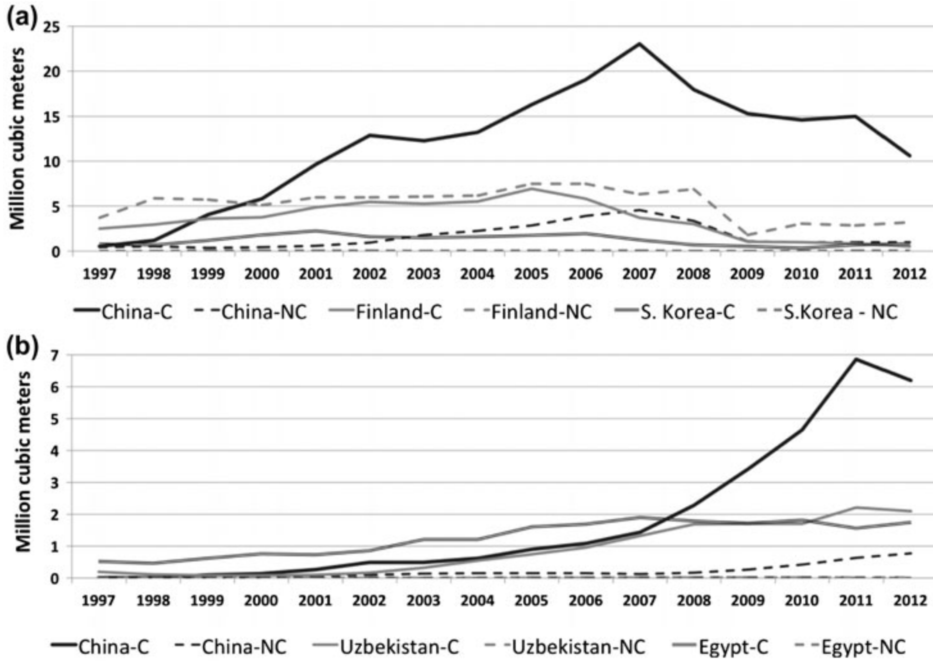

Figure 6. Major destinations for Russian coniferous and non-coniferous (a) roundwood log and (b) lumber exports, 1997–2012.
Source: Global Trade Atlas 2013.

they are gradually decreasing roundwood export tariffs to close to pre-2007 levels (Federal Russian Duma 2012). Whether Russian sawnwood and other value-added products can compete on the global market without significant subsidies and export tariffs is highly questionable. A 2012 audit of the Khabarovsky Kray forest sector, for example, revealed that the region's 173 logging companies and 87 timber-processing companies all operated at a loss (Forest Industry Online 2014).

The sector faces other challenges to more substantial processing capacity. Corruption and an uncertain investment climate continue an ongoing, pervasive short-termism. As one RFE forest sector employee noted, "It is much easier to buy and sell and there are many companies that do not want to deal with production. It is difficult to produce anything" (as cited in Simeone 2013b, 68). Other factors relate to the lack of global competitiveness, especially in terms of labor costs, as well as the emergence and persistence of small enterprises, many of whom lack the resources to modernize equipment and invest in local infrastructure, including building and maintaining roads (Nystén-Haarala and Kotilainen 2009).

Illegal logging and institutionalized corruption

These market shifts, coupled with the explosion in the number of actors spatially dispersed across the forest landscape, coincided with unfortunate changes in forest governance and the general weakening of the Federal Forest Service (Minleskhoz), which with Minlesprom formed the basis of Federal Forest Agency (Rosleskhoz).

Responsible for managing and regulating the use of Russia's forests, Minleskhoz was weakened significantly as was the Committee on Environmental Protection (Goskompriroda), the country's primary federal regulatory agency for resource use. Unlike the privatization of the *lespromkhozy* that took place through Minlesprom, the basic structure of Minleskhoz remained essentially intact. But inadequate funding, repeated changes to the Federal Forest Code, and internal corruption rendered it largely ineffective. Minleskhoz had 81 regional forest services – roughly corresponding to a respective administrative region (e.g. *kray*, *oblast*) of the Russian Federation – that in turn managed local forest service units or *leskhozy*. These *leskhozy* regulated the activities of the *lespromkhozy*, 80–90% of the funding for the *leskhozy* was supposed to come from the federal budget, with the remainder covered by the *leskhozy* themselves. In most cases, however, they received far less (Pye-Smith 2006; Sheingauz 2004).

By the mid-1990s, the large number of timber harvesters and exporters, in combination with the growing inability of impoverished and corrupt Russian government agencies to regulate these operators properly, led to a sharp rise in illegal logging throughout much of Russia (Newell 2004; Vandergert and Newell 2003); a situation that persists to this day. After years of official statements trivializing the issue, numerous Russian government officials admit illegal logging is a significant problem. Ministry of Natural Resources officials have gone on record by publicly stating that 1 in 10 trees harvested in Russia is illegal (Environment News Service 2008). In 2013, the Rosleskhoz department head, Alexander Mariev, addressed the public at a widely publicized press conference in Moscow about the prevalence of illegal logging (RIA News 2013).

How to define illegal logging is subject to considerable debate. The late forest economist Aleksandr Sheingauz once quipped that if illegal logging is a violation of forestry practices, then all logging in Russia would be illegal (Newell 2006). The most recent iteration (2007) of the Russian Forest Code does not even have a definition of "illegal logging." In this paper, we use the term "illegal logging" to denote harvest without proper documents, harvest outside of areas permitted for logging, harvest in volumes in excess of that permitted, harvest of species growing in the leased areas that are not permitted for logging, and harvest of high-quality timber in areas where only low-grade harvest is permitted. We also include the abuse of short-term (one to two year) permits that are designed for non-commercial or intermediate timber harvesting operations, which includes "salvage," "sanitary," and "maintenance" logging (hereafter, "sanitary" logging denotes all forms of intermediate harvest). All are intended to improve the health of forest stands by removing old and ill trees and trees that pose a threat for forest fire or other ecological reasons. By the mid-1990s, to secure steady revenue, *leskhozy* officials were widely abusing these permits and either conducted the logging themselves or issued permits to companies to do so. As one analyst put it, *leskhozy* administrators were forced to "switch from doing intermediate cutting for the purpose of stand improvement, to undertaking commercial high-grading for immediate returns" (Sheingauz 2004, 18). In other cases, rather than to augment meager budgets, this logging loophole has enabled unscrupulous officials to simply enrich themselves (Newell 2004).

Generally, exempt from lease payments and stumpage fees, sanitary logging licenses open up timberlands not available for long-term concession, including in protected area designations, along river systems, and on steep slopes. They also provide access to species (e.g. Korean pine) forbidden for harvest under commercial logging regulations, as harvesting during "thinning" operations allows these trees to be cut "legally." Thus, a high percentage of "commercial" harvesting began to occur under the aegis of sanitary logging, often in forest areas unavailable for commercial lease.

The forest sector as an underlying cause of forest change and degradation

How have the industry restructuring and perverse devolution of forest governance shaped the Russian forest landscape accordingly? Due to still lower production volumes, the dominant narrative has been that the timber industry, as a whole, has had less impact on the forest in this post-Soviet era than during the high Soviet period. Indeed, since the dissolution of the Soviet Union, only a portion of the Annual Allowable Cut (AAC) has annually been utilized; it was less than 28% in 2010 (FAO 2012). This is somewhat misleading, however. In some regions, the AAC may not accurately reflect the state of the forest resource. The inventory upon which the AAC is based has been repeatedly criticized for using outdated and inaccurate data. Studies have shown that *leskhozy* administrators have political and economic incentives to under-report problems and exaggerate accomplishments (Alexeyev, Markov, and Birdsey 2004; Houghton et al. 2007). In addition, a significant portion of the AAC is infeasible to cut, be it for lack of infrastructure, distance from consumer market, or small-diameter timber stands (such as the permafrost-bound larch forests that carpet the Russian boreal). Finally, at national, regional, and sub-regional scales, the AAC does a relatively poor job of indicating the state of the forest. Even at the *rayon*, or sub-regional, level, for example, there can be unsustainable logging in specific areas, but overall harvest is still below the AAC for the *rayon* as a whole.

Interviews with forestry officials, industry officials, and NGOs, as well as fieldwork and published literature, indicate a general consensus, however, that the current forest degradation underway in Russia is not due to overall harvest levels per se, but rather due to the intensive (and often illegal) harvest of high-value timber species in selected, commercially valuable and accessible forests. There has been an increase in high-grade logging, whereby only large-diameter trees are felled (Newell 2004). Weak demand for value-added products in export hastened the demise of Russia's wood-processing capabilities. Woodchips, branches, and smaller logs formerly used to make sawnwood, plywood, and pulp and paper are left at logging sites – increasingly already enormously wasteful operations – and provide fuel for potential forest fires.

These patterns of harvest are driven, in part, by export demand and preferences (i.e. consumption patterns) as they influence where the timber is harvested, what type of wood is produced (e.g. logs rather than higher value-added products), and the type of species logged. In the highly export-dependent RFE, timber harvest has gradually shifted from the northern parts of that region to areas closer to export infrastructure (i.e. road, rail, and ship) in the southern part of the RFE. Both Primorsky Kray and Khabarovsky Kray, biodiverse and forest-rich regions that share an expansive border with China, have become growing timber centers, accounting for 70% of total RFE production in 2011, up from 51percent in 1989 (Table 1). These two *krays* are among Russia's biggest exporting regions to China. In 2011, Khabarovsk Kray exported one-third of all Russian roundwood bound for China, followed by Irkutsk Oblast (22%), Primorsky Kray (11%), and Krasnoyarsk Kray (10%) (Simonov, Shvarts, and Progunova 2011). Conversely, the relative importance of northern regions (e.g. Republic of Sakha, Kamchatka) to overall production in the RFE has declined due to higher energy and comparatively higher transport costs to export logs to the North-East Asian markets. Analysis of relative harvest intensity (m3 per ha) in the RFE in the post-Soviet

Table 1. Average timber production volumes and production intensity in administrative regions of the Russian Far East.

		Primorsky Kray	Khabarovsky Kray	Amur Oblast	Sakha Republic (Yakutia)	Kamchatka	Sakhalin Oblast	Magadan Oblast
Average timber production (m^3 per ha)	(a) 1951–1953	0.251	0.138	0.099	0.014	0.014	0.569	0.022
	(b) 1987–1989	0.520	0.199	0.225	0.021	0.022	0.522	0.008
	(c) 2009–2011	0.284	0.090	0.055	0.007	0.004	0.042	0.001
Percent change	(a) vs. (b)	+107%	+44%	+127%	+56%	+55%	−8%	−61%
	(a) vs. (c)	+13%	−35%	−45%	−50%	−74%	−93%	−96%
	(b) vs. (c)	−45%	−55%	−76%	−68%	−83%	−92%	−91%

Note: Data for Chukotka Autonomous Okrug and Jewish Autonomous Oblast, although provinces of the Russian Far East, are not available. Positive (+) percent changes indicate increases in production intensity over the comparison years, while negative (−) percent changes indicate decreases in production intensity.
Source: Compiled by the authors based on data from International Institute for Applied Systems Analysis (2007) and Russia's Federal Statistics Service EMISS (2013).

period indicates a similar southerly shift. There are large decreases in harvest intensity in the more northerly regions, while the decreases in harvest intensity near the border provinces are not as severe (Table 1).

This shift in logging and the resulting changes to forest cover are partially borne out by remote sensing studies, which generally indicate a clustering rather than an even distribution of forest cover change in post-Soviet Russia. Some of this clustering is the result of large-scale forest fires, such as in the Lena River Basin in Yakutia. But in a synthesis study of forest change in Russia from 2000 to 2005, Achard et al. (2006) also identified areas of relatively rapid change in areas where harvest, including wide swaths of European Russia, southern Central Siberia, and the southern Russian Far East, is primarily for export. In these regions, they attributed timber harvest as the primary driver of forest degradation. Annual change rates of six test sites in Russia ranged from 0.31 to 6.1%. Similarly, Wendland et al. (2011) found high disturbance rates in a swath of temperate forest in Northwestern Russia, especially in Karelia, which borders Finland. Based on study sites in Central Siberia, Bergen et al. (2008) used Landsat to document an increase in younger, deciduous forestland from 1974 to 2001.

The driving forces of forest dynamics represent a complex interplay between socioeconomic structures and ecology, past and present (Williams 2006). The sheer size of Russia's forests, coupled with the surprisingly wide range of forest types, climates, and disturbances, makes evaluating the underlying causes of forest change difficult. So to explore timber harvest and export demand as drivers of forest degradation, we briefly turn to a case study of the forests of the Sikhote-Alin.'

Under the canopy: logging in the Sikhote-Alin' mountain range

Escaping glaciations during both the Pleistocene and Holocene, the conifer–broadleaf forests of the Sikhote-Alin' Mountain range in the RFE have evolved to become among the planet's most biologically diverse temperate forests (Figure 7; Krever et al. 1994). Tree species of the boreal forest (spruce and fir) thrive here together with temperate and subtropical species such as Korean pine and valuable hardwoods, including Mongolian oak (*Quercus mongolica*), Manchurian ash (*Fraxinus mandschurica*), linden (*Tilia amurensis*, *Tilia manshurica*), and Japanese elm (*Ulmus propinqua*). These forests, which extend more than 1000 km north to south through two of Russia's administrative regions (Primorsky Kray and Khabarovsky Kray, between 43 and 48° N), just east of the Chinese border, support some of the highest densities of endangered species in Russia. The estimated 400 remaining Siberian tigers (*Panthera tigris* altaica), the world's largest cat, live almost exclusively in these forests (Carroll and Miquelle 2006). Similar forests once covered areas of China, Korea, and Japan (Kim and Manyko 1994), but now remain only in relatively isolated tracts due to extensive logging and conversion for agriculture (Krestov et al. 2006). In 2001, UNESCO designated the Sikhote-Alin' Nature Preserve and adjacent river ecosystems a World Heritage Site (UNESCO 2013).

Due to its geographic proximity to China and Japan, the presence of a well-developed transport infrastructure, and commercially valuable forests, the Sikhote-Alin' is the most important timber-producing region in the RFE. However, selective logging is the predominant form of harvest there because of the mountainous geography and monsoon summer rains (Sheingauz 2003). This form of harvest leads to many small disturbances under the forest canopy, often at too fine a resolution for remote sensors (e.g. Landsat) to detect. For this reason, remote sensing studies of the region have not detected large

Figure 7. Forests of the Sikhote-Alin' range in the southern Russian Far East.
Source: Newell, 2004. Reprinted with permission.

disturbances overall. Previous analysis of Intact Forests Landscapes (IFL) (Potapov et al. 2008) over the Sikhote-Alin' showed that just 7% of forests identified as IFLs were burned and 13% logged at some point between 1970 and 2008 (Loboda et al. 2012). The global map of forest cover change (2001–2012) by Hansen et al. (2013) also indicates a very low rate of disturbance.

Research by scholars and NGOs, however, indicates a different picture of disturbance under the Sikhote-Alin' canopy. Much of this work has focused on illegal logging and related trade with China (EIA 2007, 2012, 2013; Krkoska and Korniyenko 2008; Lebedev 2005a, 2005b; Northway and Bull 2007; Pye-Smith 2006; Smirnov et al. 2013; Stark and Cheung 2006; Simonov, Shvarts, and Progunova 2011; Simonov and Dahmer 2008; Weiming et al. 2005; Zherebkin 2011). Within the Russian government, illegal logging is thought to be more severe in regions (such as the Sikhote-Alin') that supply export markets and often involves the active participation of foreign actors. As one member of Russia's Federal Duma's Committee on Natural Resources commented:

> Unfortunately, we have some problems with relationships regarding exports in the Far East connected to problems with illegal logging, including the participation of our neighbors. It is no secret that a significant number of illegal felling and harvesting in the Far East involves Chinese companies. (cited in Simeone 2013b, 55)

Scholars have long made attempts to quantify the extent of illegal logging in Russia, as well as its flow to China. Robbins and Perez-Garcia (2012) estimate that, in 2007, actual timber consumption in China exceeded officially reported consumption by approximately 45%, attributing the discrepancy to under-reporting Chinese import volumes as well as log production in China. Using timber production and export data, and log conversion ratios, Smirnov et al. (2013) concluded that two-to-four times more Mongolian oak was logged for export to China than legally permitted through commercial harvest between 2004 and 2011. As the area in which Mongolian oak can grow is almost exclusively restricted to the Sikhote-Alin' (as is true of a number of other hardwood species), the researchers were able to control for leakage in terms of wood being harvested from other regions and then exported through major export points in Primorsky Kray and Khabarovsky Kray.

In addition, the Smirnov et al. (2013) study summarizes fieldwork conducted with Russian forest service officials over more than a decade at 11 case study sites in the Sikhote-Alin'. A number of these study sites indicated illegal logging volumes far exceeding the AAC for some species. Research in the Dalnerechensky Leskhoz region found dramatic under-reporting by forestry officials of illegal log volumes over a 10-year (2001–2011) period. The study also provides detailed evidence of commercial logging under the guise of "sanitary" logging at many study sites, including in areas protected from commercial harvest, such as in wildlife refuges (*zakazniki*), protected nut zones, and other sensitive ecological zones (e.g. mountainous slopes and river floodplains). Based on Russian production statistics, this intermediate logging appears to be extensive. The Primorsky State Logging Enterprise, a branch of the Primorsky Forestry Agency, logs an estimated 500,000 m^3 annually through sanitary logging licenses, making it one of the largest timber harvesters in the entire Primorsky region (Smirnov et al. 2013). For the RFE as a whole, production from sanitary logging in 2010 totaled an estimated 3.5 million m^3 (Kovalev et al. 2011) or almost half of the total production from traditional commercial harvest.

What this study repeatedly documents, as do others, is that illegal logging is focused on Korean pine, spruce, and selected hardwoods (oak, ash, elm, and linden). These species are largely exported to China. Mongolian oak, especially, is in high demand by the Chinese furniture and flooring industries (Appendix 1 details export of Russian oak to China, 1997–2012). Considerable stands of oak remain, but economically accessible, high-quality, large-diameter stands are in short supply. A significant percentage of what does remain is found not in long-term concessions but in areas restricted from commercial harvest. Given continued high prices for these species, the financial incentive is strong for forest service units to issue sanitary logging permits in areas protected from commercial harvest.

Areas protected from commercial harvest have been zoned accordingly for a reason. Commonly cited impacts from intensive logging in these zones include the depletion of rare and endangered forest species, degradation of protected area habitat, and lowland flooding. As noted earlier, traditional remote sensing methods have not been able to spatially quantify forest degradation and change due to this selective, intensive harvest. But field research by wildlife biologists found a strong negative correlation between the prevalence of logging roads (including those constructed for sanitary logging) and habitat fragmentation and species decline in the region. Kerley et al. (2002), for example, have documented the influence of logging roads on female tiger and cub survival. The depletion of Korean pine stands has been well documented for decades. A 1989 ban on commercial harvest of the species was lifted in 2007, before all forms of harvest were banned in 2010 (WWF 2010). Numerous scientists (Dunishenko and Darensky 2006; Yudakov and Nikolaev 2012) attribute the region's widespread decline in ungulate populations (especially wild boar and red deer) to the depletion of oak and Korean pine, because both tree species provide essential food sources (in the form of nuts) for these ungulates. Intensive harvest of linden, a crucial tree for pollinators, has led to conflicts between bee-keepers and loggers as traditional "no-cut" zones around forest apiaries are impinged upon (Smirnov et al. 2013). More research is needed, however, to document and quantify the environmental impacts from logging under the canopy of the Sikhote-Alin'.

China's growing ecological shadow?

What, then, is China's responsibility for this forest degradation? Studies document how demand among Chinese furniture and flooring manufacturing for specific species that grow in these forests – especially Mongolian oak, Manchurian ash, and a selection of few other species – is fueling the abuse of "sanitary" logging permits (Newell 2004; Smirnov et al. 2013). This demand can be partially attributed to the National Forest Protection Plan, which the Chinese government enacted to protect the country's few remaining "natural" forests, to control water levels and to prevent soil erosion, which reduced timber harvests throughout much of China (Sayer and Sun 2003). Since 1998, China has seen a massive increase in imports and is now the world's largest importer of wood products (Sun 2014), and as noted earlier, Russia has been by far the largest supplier (Figure 8).

On the surface, this is a clear example of one country externalizing environmental costs at the expense of another country in an effort to enhance its own environmental security. Indeed, this has been the dominant narrative in the literature. Mayer et al. (2005), for example, focused on how the Chinese Plan effectively exported ecological impact to Russian forests. Similarly, Kallio, Moiseyev, and Solberg (2006) found

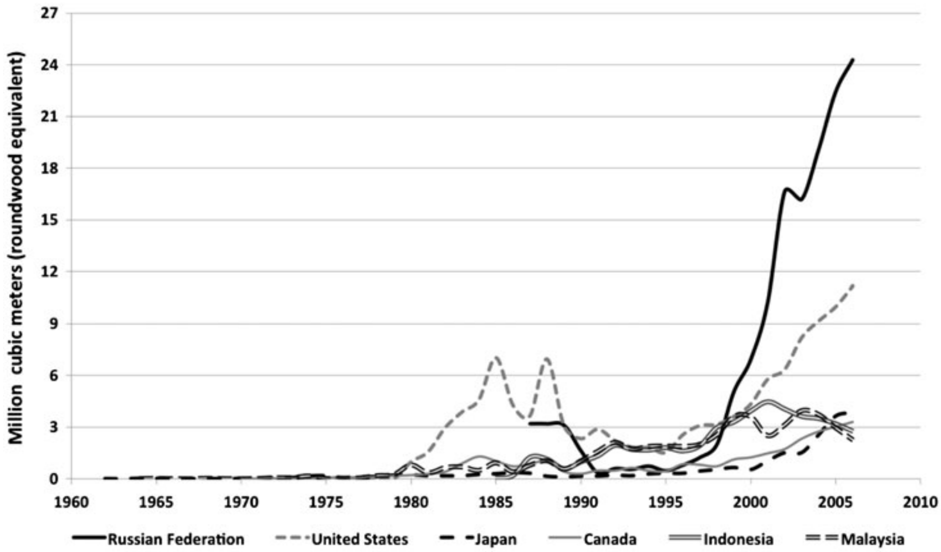

Figure 8. Major source countries of China's forest product imports, 1962–2006.
Source: Forest Products Trade Flow Database of the European Forest Institute (2009).

evidence that restricting timber production in Europe led to increased harvest in northwest Russia. But analysis of how and where Russian timber is ultimately being consumed reveals a more nuanced narrative: China is a manufacturing node along a complex, transnational commodity chain.

In 1997, China was a net importer of plywood, and the majority of Chinese production was skewed towards low value-added projects (Figure 9). By 2007, it was the world's largest exporter of finished wood products (e.g. furniture, flooring, and plywood). Pivotal to the country's emergence as a manufacturing juggernaut was Taiwanese investment, as rising labor wages in Taiwan were cutting into profits; further influencing the emergence was an array of subsidies and incentives from the Chinese state. The next wave of capital and technology came from US manufacturers, such as Ashley Furniture and Armstrong Flooring. But rather than building factories, they contracted Chinese Original Equipment Manufacturers (OEMs) to produce product. Do-It-Yourself or "big-box" retailers such as Ikea, Walmart, and The Home Depot also began to outsource their manufacturing to OEMs. Ikea was an early adopter, so by 2009 it had supply contracts with more than 300 Chinese OEM factories, which produce approximately one-quarter of the solid wood furniture that Ikea sells (Goodman and Finn 2007). Russia is the largest source of wood for Ikea products, approximately 20% of that company's worldwide supply (Goodman and Finn 2007). Based on data from China's General Administration of Customs, the majority of China's exports to the United States are from OEMs (Li 2014).

In 2011, China exported $25.4 billion in value-added wood products, including $12.8 billion in wooden furniture.[5] Almost one-quarter of this total was exported to the United States, including wood furniture totaling $3.4 billion. The other major export markets are Japan, the UK, and Germany. The highest value export category ($7.1 billion) was Wooden Furniture NESOI (or "Not Elsewhere Specified or Included"), and

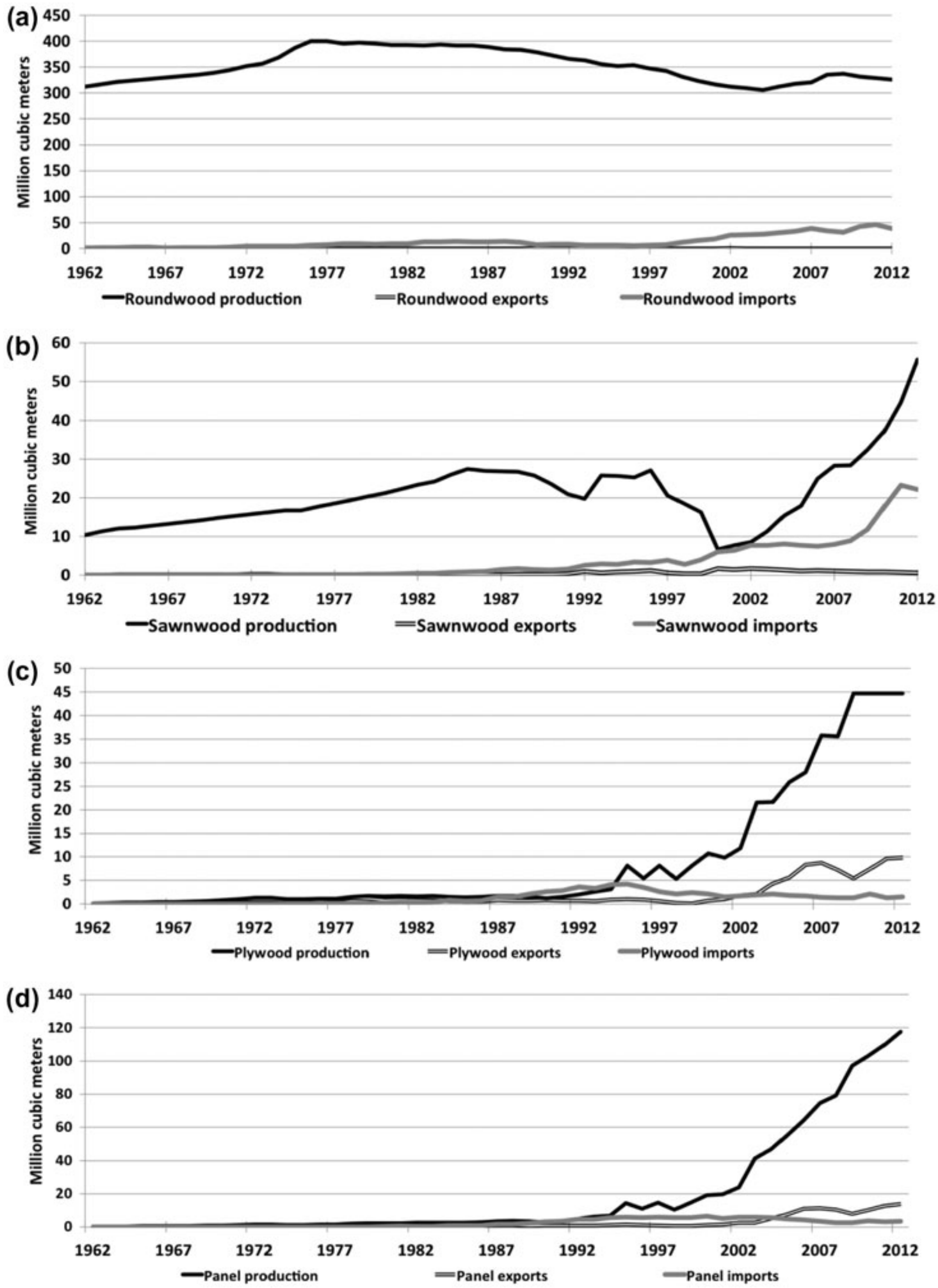

Figure 9. Production, export, and import of forest products from China, 1961–2012. Figure is by forest products: (a) roundwood; (b) sawnwood; (c) plywood; (d) wood-based panels (includes fiberboard, particleboard, and plywood).
Source: UN FAO (2013).

includes items such as folding wardrobes, hanging clothing bars, rigid shelves for clothing organization, and hard lid boxes. Almost one-third of exports in this category

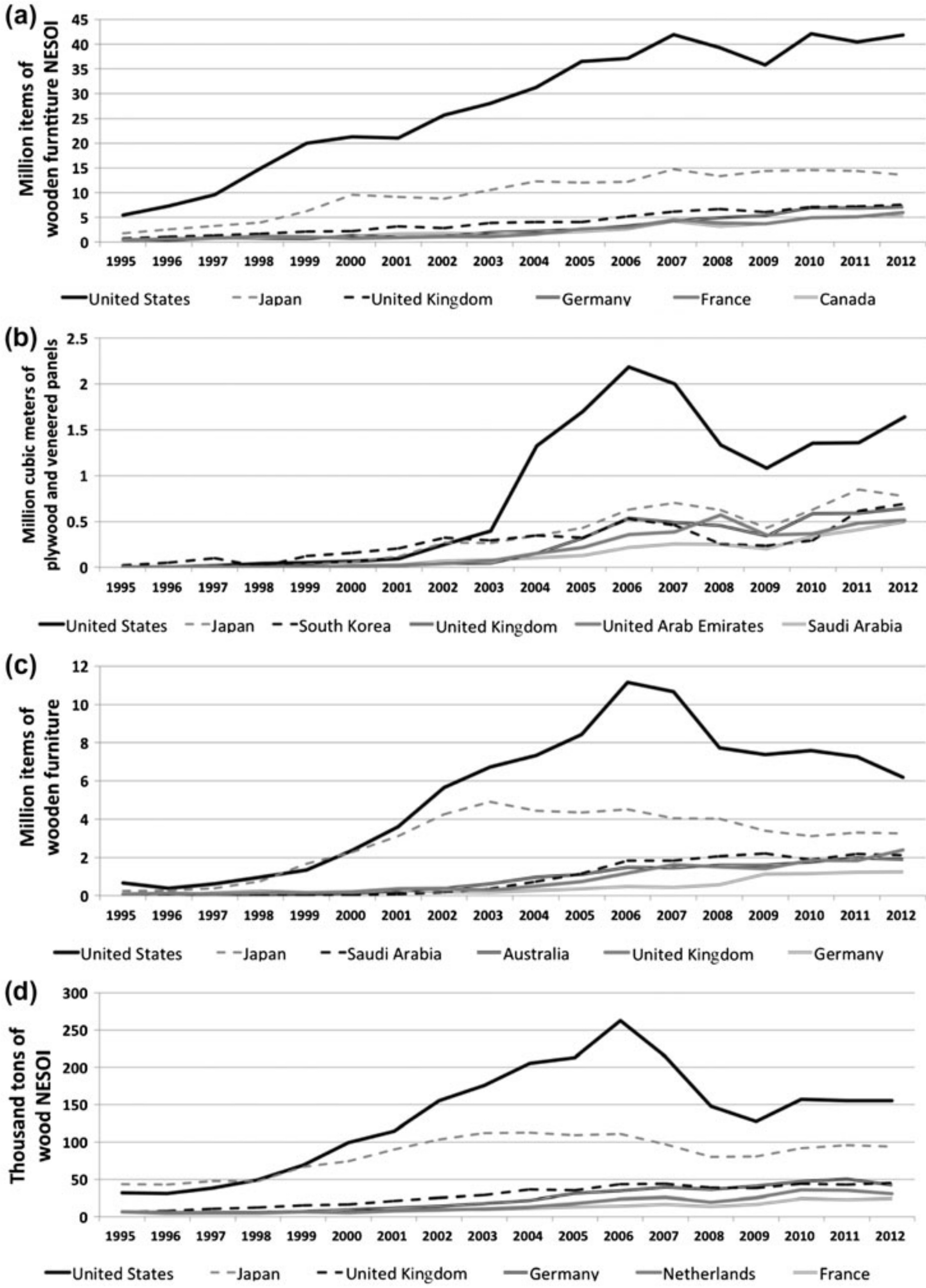

Figure 10. Major destinations for Chinese wood exports by forest product category, 1995–2012. Figure is by China's four highest value exports of forest products: (a) wood furniture NESOI; (b) plywood and veneered panels; (c) wooden bedroom furniture; (d) wood NESOI.
Source: Global Trade Atlas 2013.

went to the United States (Figure 10(a)). Plywood and veneer panels are the second highest value category ($2.7 billion), with 16% of exports destined for the US

(Figure 10(b)). Twenty-one percent of Wooden Bedroom furniture ($2.7 billion), the third highest value category, went to the US (Figure 10(c)). Exports of wood NESOI, products like clothes hangers and clothespins, totaled $1.7 billion, with 24% going to the US (Figure 10(d)).

The research NGO Forest Trends estimated that, in 2005, roughly two-thirds of China's total timber imports were used to produce China's wood product exports (furniture, flooring, plywood, and other finished wood products), with the remaining one-third for domestic purposes (Sun, Cheng, and Canby 2005). This ratio has shifted somewhat due to rising domestic consumption in Chinese cities, but the portion of wood imported for the production of exported goods is still very high. The specific uses of Russian timber are difficult to track as wood is used in factories throughout China. We do know that its uses vary by species. Scotch pine (*Pinus sylvestris*), for example, is largely used domestically within China's construction sector, although many IKEA products are made from Scotch pine in China and then exported (Weiming et al. 2005). In contrast, hardwoods from the Sikhote-Alin' are used primarily in China's furniture and flooring industries, which have a strong export orientation. NGOs, such as the Environmental Investigation Agency, have used customs data and undercover fieldwork to track flows of these hardwoods into factories and warehouses in China and then on to showrooms of major retail companies in the United States, including Walmart and Lumber Liquidators (EIA 2007, 2013).

Tracking Russian wood to the end consumer in this manner and more broadly by looking at aggregate trade flows reveal a complex ecological shadow of which China plays a part, but so do final consumers of these products in the United States and Europe. We have only provided a rough accounting of the flow analysis for Russian timber to the end-consumer. More research to quantify and contextualize these transnational wood flows and assess their role as a driver of forest degradation would be a useful addition to the literature. This could include, for example, the percentage of Sikhote-Alin' oak and ash exported to China that ends up on international markets in the form of finished wood products.

Discussion and conclusion

Russia has a long history of deforestation and forest degradation, the ecological conditions of which are fundamentally intertwined with the evolving structural features of industry, trade, and governance. Underlying causes of forest change and degradation are a complex interaction of natural and anthropogenic disturbances that vary across time and space. This paper has focused on the role of the Russian forest sector, illustrating how shifting production–consumption dynamics affect land cover and land use accordingly. Timber production and trade data reveal the rapid transition of the sector into a raw material base for the global economy. Demand in export markets, combined with the spatial fracturing of the industry across the forest landscape and impoverished (and often corrupt) forest management, has led to forest degradation patterns in Russia quite different from that in the Soviet period.

A brief case study of the Sikhote-Alin' region supports the hypothesis that decline in forest quality stems from unregulated intensive harvest of high-value timber species in accessible forests, rather than overall levels of timber harvest per se. To access these resources, watersheds "closed" for commercial harvest are accessed using sanitary logging permits. Traditional remote sensing approaches generally have been at a spatial scale too coarse to effectively register these disturbances. New change-detection algorithms for radar, however, have the potential to more accurately quantify the extent and rate of the selective logging (commercial, intermediate, and illegal) in mountainous regions such as the Sikhote-Alin' (Marino, Cloude, and Woodhouse 2012). Other future scientific research needs to include extensive fieldwork to better understand the multifarious ecological (and socioeconomic) impacts of these selective logging practices.

In terms of improved governance, recommendations to ameliorate forest degradation in Russia have been production centric – largely confined to more effective forest legislation, government agency reform, and calls to cull corruption and mafia influence. Forestland remains the property of the state, and although there are periodic calls to privatize it, this is a minority opinion amongst those in the sector (LesVesti 2014). More significantly, the Russian government has attempted to decentralize forest management and use through repeated revision (1993, 1997, 2006) of the Federal Forest Code (Hitztaler 2011). The 2006 revision tried to address forest service corruption – especially the abuse of sanitary logging licenses – by effectively dividing provincial forest services into three separate departments: forest management, inspection and monitoring, and commercial institutions. But this restructuring has not had much of an effect. NGOs advocate the creation of multi-agency inspection teams to combat collusion with individual officials and a survey of timber stocks, especially for hardwoods (Smirnov et al. 2013). Should such a survey reveal significant differences with forest inventory records, then this would ostensibly necessitate reducing the annual allocable cut for selected species.

These are necessary reforms indeed, but proposed solutions also have to consider powerful external forces, which are part and parcel of a broader, interdependent web of global connections. Exploration of how the forces of consumption (e.g. market demand, retailer and consumer preferences) affect forest change and degradation leads one to consider how they might be harnessed to improve forest governance and resource use. This moves the discourse beyond how Russian forestry agencies can reduce waste in the timber production process, so that questions would also include the following: Who is ultimately consuming the harvested wood? Is the level of consumption of Russian wood sustainable? And, who benefits along the commodity chain and who loses?

In recent decades, we have witnessed the rise of an "ethical" consumption movement, which seeks to harness consumer power as a pathway to a more humane and sustainable world. This is based on the conviction that buyer- (or retailer-) driven commodity networks can use quality conventions and standards (e.g. certification, corporate social responsibility policies) to improve environmental governance and reduce social injustice in producing and manufacturing regions, such as Russia and China. Supermarkets and stores today are filled with products – such as fair trade coffee, organic food, sweatshop-free apparel fashion, and conflict-free diamonds – that certify some degree of traceability and sustainability.

Thus far, with respect to Russia, forest certification has been the primary instrument to rescale environmental governance. Russia is second only to Canada in terms of total forestland certified by the Forest Stewardship Council (FSC). The catalyst for this is not demand in Russia for such products, but rather the global marketplace. After interviewing more than 100 stakeholders in the sector, Ulyabina and Fennell (2013, 182) concluded that certification remains "an imported Western phenomenon, driven by forces outside of Russia." One of these driving forces are NGO "markets" campaigns, which in the wood product sector have traditionally focused on Do-It-Yourself retailers, such as Walmart, Staples, and Home Depot (O'Rourke 2005). But there is an emerging advocacy effort underway that broadens responsibility to include other "consumers" by including importers and manufacturers. In 2008, an NGO coalition effectively lobbied the US Congress to amend a long-standing wildlife statute (the Lacey Act), making it illegal to export to the United States any plant product obtained in breach of the law, including timber products (Gregg and Porges 2008). This revised Lacey Act was first used as an instrument by NGOs in a case against Gibson Guitar Corp, which was found to be guilty of importing illegally logged ebony and rosewood from Madagascar to make its guitars (Itzkoff 2009). In theory, under the Lacey Act, the government may seize goods made from illegal wood, regardless of whether or not the manufacturer knew it was illegal. The European Union and other major wood-importing countries have since passed similar legislation (Simeone 2013a). NGOs are already using the Lacey Act in the case of Russia. In 2013, the Environmental Investigation Agency (EIA) issued a study that reportedly uncovered the use of illegally logged Russian hardwood by Lumber Liquidators, the largest retailer of hardwood flooring in the United States, causing the US federal government to raid that corporation's offices (EIA 2013; Rubin and Banjo 2013).

This paper has provided an initial and partial accounting of how Russian wood flows into factories in China and subsequently is turned into flooring and furniture that is ultimately consumed in the United States, Western Europe, and Japan. We have roughly tracked these flows to demonstrate how ecological shadows (Russian forest degradation) extend to many parts of the planet and how they shift depending on ever-evolving global supply chain configurations and consumption patterns. To extend this research, we suggest conducting a full material flow analysis (MFA) of Russian timber stocks and flows over time space, as has been done for China (Cheng et al. 2010) This would reveal more complete production–consumption flows, but it could also serve as the basis for a systems dynamic model that develops functional relationships broadly specifying how much cutting of what species is occurring in relation to disturbance rates and changes in forest composition. By downscaling to a specific region, such as Primorsky Kray, one could construct and parameterize a model to represent the coupled system of production and trade in forest resources and forest landscape dynamics. This would then allow one to assess the relative weight of market-driven vs. natural (e.g. fire) disturbances for the Sikhote-Alin' forests so as to perform coupled analysis of resources flows and forest processes, such as future change scenarios based on projected timber demand.

As Russia is annually among the world's largest exporters of natural resources (WTO 2010), other sectors in Russia would benefit from an MFA approach, specifically, and through the lens of a global production–consumption dynamic, more generally. In many respects, the Russian fisheries sector resembles the timber sector. In the Sea of Okhotsk, Sea of Japan, and the Bering Sea, commercial fishing essentially targets species in demand on export markets; namely crab, pollock, sea urchin, and salmon (Newell 2004). This has sharply reduced stocks of some species, leading to harvest restrictions and even temporary closures of fishing zones. In the United States, Russian seafood has been targeted through the Lacey Act, with the US government seizing imports of king crab illegally harvested from Russian waters (Bernton 2011). Other extractive industries in Russia with global supply chains include oil and gas; gold, diamonds, platinum, and other precious metals; and the harvest and trade of endangered species.

Thinking through consumption influences how one theorizes environmental change. This paper has provided an analytical approach that considers *consumption* as fundamental as *production* when framing, diagnosing, and addressing issues of the environment. This unveils how consumption patterns and processes influence ecosystems and socioeconomic relations in resource and manufacturing peripheries far beyond regions and national borders. In the process, the concept of "region" becomes more dynamic. Places become less discrete and self-contained and more porous and partial. In our analysis of the post-Soviet forest sector, "Russia," the "Russian Far East," and the "Sikhote-Alin' Mountains" retain their uniqueness as regions, while also being mediated and shaped by processes of globalization. Perhaps, it is this complicated economic interdependence with West – woven together by flows of timber, oil, gas, and gold – that may ultimately temper Russia's geopolitical designs and expansionist tendencies.

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Notes

1. Approximately, 68% of Russia's forests is composed of coniferous species, with deciduous species (22%) and tundra-type species (9%) making up the remainder. Russia has 1.2 billion ha of forest land, with the predominant species being larch (31% of the total), pine (20%), birch (14.4%), and spruce (13.4%).
2. There are exceptions of course. See, for example, Andonova, Mansfield, and Milner 2007; Oldfield, Kouzmina, and Shaw 2003; Ryzhova and Ioffe 2009; and Stokke 2000.
3. Dauvergne (1997) defines ecological shadows of a national economy as the "… aggregate environmental impact on resources outside a country's territory based on three sets of factors: (1) government policies and practices, especially Overseas Development Assistance (ODA) and loans; (2) corporate conduct, investments, technology transfers, and purchasing and distribution patterns; and (3) trade, including export and consumer prices, amount and type and consumption, and import barriers."
4. Numerous scholars have examined economic efficacy of these structural adjustments. See, for example, work by Solberg et al. 2010, Simeone 2012, Simeone and Eastin 2012, and Simeone 2013a, as well as studies of their impact on the roundwood market globally by Turner et al. 2008, Eastin and Turner 2009, Solberg et al. 2010; and van Kooten and Johnston 2014.
5. Forest products are all those that fall under the HS code series beginning with "44." Wooden furniture includes the following HS codes: wooden office furniture (940,330), wooden kitchen furniture (940,340), prefabricated buildings (940,600), wooden bedroom furniture (940,350), and furniture NESOI (940,360). Wooden Furniture NESOI is HS Code 940,360. Plywood is HS Code 4412. Wooden bedroom furniture is HS Code 940,350 and Wood NESOI is HS code 4421.

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Appendix 1. Russian oak exports (roundwood and sawnwood) to China, 1997–2012

	Oak roundwood (m^3)	Oak sawnwood (m^3 roundwood equivalent)	Total (m^3 roundwood equivalent)
1997	34,575	4218	38,793
1998	52,065	2838	54,903
1999	72,150	6536	78,686
2000	137,142	23,336	160,478
2001	135,525	63,520	199,045
2002	148,393	72,607	221,000
2003	249,156	106,457	355,613
2004	407,549	115,977	523,526
2005	609,758	139,039	748,797
2006	703,690	139,213	842,903
2007	810,239	98,773	909,012
2008	826,535	82,857	909,392
2009	198,301	175,889	374,190
2010	144,538	347,025	491,563
2011	93,444	405,275	498,719
2012	89,556	382,479	472,035

Note: Coefficient for calculating m^3 of sawnwood to roundwood equivalent m^3 of sawnwood based on methodology of Smirnov et al. (2013).
Source: Global Trade Atlas (2013).