12-1-2008

Environmental issues in Russia

Laura A. Henry
Bowdoin College

Vladimir Douhovnikoff
Simmons University

Environmental Issues in Russia

Laura A. Henry[1] and Vladimir Douhovnikoff[2]

[1]Department of Government and Legal Studies, Bowdoin College, Brunswick, Maine 04011; email: lhenry@bowdoin.edu

[2]Department of Biology, Simmons College, Boston, Massachusetts 02115; email: vlad@simmons.edu

Annu. Rev. Environ. Resour. 2008. 33:437–60

First published online as a Review in Advance on June 2, 2008

The *Annual Review of Environment and Resources* is online at environ.annualreviews.org

This article's doi: 10.1146/annurev.environ.33.051007.082437

1543-5938/08/1121-0437$20.00

Key Words

climate change, forests, international environmental regimes, nongovernmental organizations, pollution, Soviet Union

Abstract

This review examines the literature available on the state of the environment and environmental protection in the Russian Federation. As the largest country on Earth, rich in natural resources and biodiversity, Russia's problems and policies have global consequences. Environmental quality and management are influenced by the legacy of Soviet economic planning and authoritarian governance, as well as by Russia's post-Soviet economic recession and current strategies of economic development. Russia achieved a reduction in some pollutants owing to the collapse of industrial production in the 1990s, but many environmental indicators suggest growing degradation. Russia has signed on to a number of international environmental agreements, but its record on implementation is mixed, and it discourages environmental activism. Scholarship on the Russian environment is a limited, but growing, field, constrained by challenges of data availability, yet it offers great potential for testing scientific and social scientific hypotheses.

Contents

INTRODUCTION 438
THE ENVIRONMENT UNDER THE SOVIETS 438
THE RISE AND DECLINE OF STATE ENVIRONMENTAL PROTECTION 439
ECONOMIC TRANSFORMATION AND THE ENVIRONMENT 441
THE STATE OF RUSSIA'S ENVIRONMENT 442
Water Quality 443
The State of Russia's Forests 445
The Effects of Climate Change 446
Air Quality 446
Radiation 447
RUSSIAN CITIZENS AND THE ENVIRONMENT 448
RUSSIA AND INTERNATIONAL ENVIRONMENTAL COOPERATION 451
CONCLUSION 453

INTRODUCTION

The Russian Federation is the largest country on Earth. As such, its environmental problems and policies have global consequences. Yet assessing Russia's environmental quality and environmental policies is challenging. Russia's biomes range from polar desert to temperate rain forest. The size and diversity of biome types, as well as the uneven distribution of human settlement and natural resource use, make it difficult to generalize about overall environmental quality. In addition, Russia has experienced immense political, economic, and social changes since the breakup of the Soviet Union in 1991. In the post-Soviet period, Russia is developing new patterns of resource use and new strategies of environmental management with changing implications for environmental quality. Public activism on environmental issues has varied with changing political and economic conditions as well. This article contextualizes scientific findings on Russian environmental quality in five issue areas—water quality, the state of forests, effects of climate change, air quality, and radiation—within a review of the social scientific literature on the political, economic, and social factors that underpin environmental protection and activism, from the Soviet period to the present.

THE ENVIRONMENT UNDER THE SOVIETS

The creation of the Soviet Union inspired ambitious claims about how a new socioeconomic system would allow humans to harness nature's power for the common good and how collective ownership of property would avoid the inequities and excesses of capitalist societies. Soviet economic theorists argued that environmental degradation was an outgrowth of private property and profit-seeking behavior and that it was therefore unlikely to be a problem in the USSR. Yet because the Bolshevik Revolution occurred before the Russian Empire had fully industrialized, the task of capital accumulation and industrialization fell to the state. Thus, early Soviet leaders prioritized industrialization above other goals, particularly emphasizing heavy industry and projects designed on a massive scale. The goal of industrialization at any cost was reinforced by the lack of a worldwide revolution of the proletariat; "socialism in one country" required the Soviets to catch up and surpass the West economically in order to ensure the state's survival.

During the Soviet period, Western scholars debated whether Marxist-Leninist ideology or the drive for rapid industrialization bore greater blame for environmental degradation (1, 2) but generally agreed that the Soviet-planned economy had resulted in severe, if regionalized, ecological damage. Although acknowledging serious deficiencies in Western states' stewardship of the environment, scholars of the Soviet environment pointed to a number of factors that contributed to declining environmental quality under the Communist system:

1. Economic planners' treatment of environmental resources such as air or water as "free" or having little value
2. Common ownership of natural resources, which did not encourage conservation by individuals or firms
3. Chronic shortages, which created incentives for state and party officials to exaggerate their resource needs and resulted in more waste
4. Militarization of the economy, which encouraged a culture of secrecy
5. The monopoly of a single party, resulting in a lack of debate about issues such as the environment
6. The sheer size and natural resource wealth of the country, which led to a sense of complacency about the environment (2–5)

The legacy of Soviet economic planning accounts for dramatically divergent levels of environmental quality across contemporary Russia. Economic planners believed that industries should be concentrated in order to gain efficiencies in investment, production, and transportation (5). As a result, a map of Russia now depicts a landscape encompassing relatively untouched natural expanses, punctuated by highly degraded areas of concentrated industry. Victor Danilov-Danilyan, the former head of the State Committee on Ecology, suggested that 55% of Russia's land has not been affected by human activity and that another 20% has been only minimally affected (6). In October 2006, however, a report from the Blacksmith Institute stated that three of the world's ten dirtiest cities are in Russia (7). These divergent evaluations underpin the debate among scholars and activists as to how to characterize Russia's environmental situation overall and determine which environmental problems are the most urgent (8).

THE RISE AND DECLINE OF STATE ENVIRONMENTAL PROTECTION

For most of the Soviet period, the task of environmental protection was fragmented across more than 15 ministries, each of which was responsible for a particular economic sector (9). The coincidence of the 1986 Chernobyl nuclear accident and Mikhail Gorbachev's glasnost, or openness, reforms of the late 1980s opened up public debate on environmentalism, revealing widespread dissatisfaction with the state's environmental management, and spurred a state response (10). In 1988, the State Committee on Environmental Protection (*Goskompriroda*) was created with the authority to conduct environmental reviews for all new projects. Environmental protection gained further stature following the collapse of the Soviet system. One of the first laws passed by the newly independent Russian Federation was the 1991 Federal Act on the Protection of the Natural Environment (11), and that same year *Goskompriroda* was promoted to the Ministry of the Environment. Russia also progressively, if mostly rhetorically, committed itself to the principle of sustainable development in the early 1990s (12). In what in retrospect may have been the peak of openness about the state of Russia's environment, a 1993 commission chaired by Aleksei Yablokov, President Yeltsin's advisor on the environment, revealed that the Soviets had disposed of 2.5 million curies of radioactive waste at sea since 1965.

***Goskompriroda*:** the State Committee on Environmental Protection, 1988–1991

From 1991 until 2000, environmental protection officials struggled to be effective under difficult conditions. State agencies charged with protecting the environment fared poorly in bureaucratic infighting, tending to have fewer resources and institutional authority relative to other bodies (13). Intense lobbying by industrial groups also eroded environmental protection over time (9). Other obstacles for officials charged with environmental protection included the lack of promised funding, almost constant bureaucratic reorganization, the lack of clarity in the legal environment, widespread corruption, and pressure for economic development. The authority of state environmental protection agencies grew until approximately 1995, but then began a slow decline that continues to the present day. In 1996, President Yeltsin reduced the status of the

***Goskomekologiia*:** the State Committee on Environmental Protection, 1996–2000

Ministry of the Environment once again to a State Committee for Environmental Protection (*Goskomekologiia*). Then, in May 2000, President Putin dissolved *Goskomekologiia* and the Federal Forestry Service by decree, passing on their responsibilities to the Ministry of Natural Resources. The strongest motivation behind the disappearance of the state committee appears to have been to encourage the exploitation of natural resources in order to jump-start the economy, an urgent task after the financial crisis of August 1998 (14, 15).

In spite of the state agencies' mixed performance, environmental advocates were indignant that protecting the environment now would fall under the purview of the ministry charged with exploiting natural resources for economic gain. Assessments of the state of environmental protection since 2001 have been largely negative. For example, in the wake of *Goskomekologiia's* dissolution, the number of environmental inspectors has been dramatically reduced. Environmentalists also were highly critical of the Duma's 2001 decision to pass a law allowing the import, processing, and long-term storage of other countries' spent nuclear fuel in Russia in anticipation of billions of dollars in revenue for the service. Their effort to gather signatures to demand a referendum on the issue was declared insufficient by the Central Election Commission (16). In 2001, Aleksandr Knorre, a sharp critic of the government, charged, "There simply is no environmental policy in Russia—the existing policy could be construed as intending to *destroy* environmental policy" (6). Other leading figures such as Yablokov (16a), the former presidential advisor, asserted that the state's policy could best be characterized as "de-ecologization," and the environmental sociologist Oleg Yanitsky (17) argued that Russia was going through a period of "demodernization." Nevertheless, several major pieces of environmental legislation have been passed since 2001, including an Environmental Doctrine (2002), a Water Code (2006), and a Forest Code (2007). Environmentalists charge that these pieces of legislation contain some valuable measures, but also many inconsistencies and omissions that make them difficult to put into practice. The persistent gap between Russia's strong environmental protection laws on paper and their weak enforcement in practice also has been a frequent criticism since the Soviet period. Bell argues that Russian environmental laws have often been "aspirational" and "set idealistic, often highly unrealistic goals" (18).

In the 1990s, responsibility for environmental protection was decentralized, with Russia's 89 (now 83) regions taking on a greater role. Whether this generally led to more effective environmental protection is a matter of some dispute. Glushenkova (13) argues that regional environmental agencies quickly surpassed federal bodies in protecting the environment, but others assert that overlapping rights and responsibilities, rather than a clearly delineated division of labor, allowed both levels of government to shirk responsibility for environmental protection. As Kotov & Nikitina state, "Having eliminated control from above, local authorities have managed to avoid democratic control and accountability before the public, which was of a particular importance in the environmental sphere" (9). Yet decentralization may have made the diminution of environmental protection agencies at the federal level less significant. In a case study of the Samara oblast, Crotty (19) suggests that environmental monitoring and control at the regional level changed very little in the first years following the dissolution of the State Committee on the Environment.

Although the country experimented with a variety of mechanisms for environmental protection, including the polluter pays principle, the creation of extrabudgetary environmental funds, and an environmental review system (*ekologicheskie ekspertizy*), there are few detailed studies of specific Russian environmental policies. Cherp's review (20) of the environmental impact assessment process in Russia since the late 1980s points out key differences in the concept in Russia as compared to the West, including the dominant role of the state and the lack of transparency. Environmental charges for air, water, and solid waste pollution collected

in environmental funds, the primary sources of financing for environmental protection in the 1990s, also have received some scholarly attention. These charges proved less effective at reducing pollution and raising funds for environmental protection than expected because fees were generally lower than the cost of new technology, fees failed to keep pace with inflation, payments were often made in goods or services rather than cash, and many firms received special dispensation to avoid payment. Kjeldsen (21) offers the most detailed study of pollution charges and estimates that in 1996 35% of environmental charges were not paid. Kotov & Nikitina concur and note, "By the end of the nineties about two hundred million dollars have been transferred annually to environmental funds: for such [a] large country as Russia this figure was quite modest" (9). The federal-level environmental fund was closed in 2002, and many regions effectively did away with their funds as well or were tempted to absorb the funds into their general budgets. Nevertheless, Larin et al. (22) suggest that financing for environmental protection has increased overall during the Putin years and that the amount spent in 2003 was three times that of 1999, although it is worth noting that the overall government budget grew substantially during this period as well.

One of the undisputed achievements of the Soviet period was the development of a system of highly protected lands (*zapovedniki*, *zakazniki*, and other designations). Evaluations of the continued survival of this system in the post-Soviet period are mixed. On the positive side, more land has been preserved, and a new system of more than 35 national parks has been created. Ostergren & Jacques (23) note that the number of *zapovedniki*, the highest level of nature preserve, increased from 77 to 100 in the 1990s, encompassing more than 33 million hectares (ha). Yet financing for the management of these lands has fallen precipitously, with budgets that are only 20% to 40% of their former size (23). Small budgets contribute to staffing and monitoring problems, and exacerbate problems of poaching and illegal timber harvesting.

Institutional, legal, and financial factors can only bear part of the blame for weak environmental protection in Russia in the 1990s. Even the most carefully designed policies had unpredictable effects in a climate of severe economic and political instability. The fluid situation made it difficult to adopt a long-term perspective and to apply even well-intentioned laws. Kotov & Nikitina offer the following evaluation of 1990s era environmental policy: "Created mostly according to their Western prototypes, new environmental mechanisms aimed at responding to environmental threats lost part of their effectiveness" when applied "within general domestic institutional framework deformed by corruption, weakness of the government at all levels, shadow economy, impacts of the interest groups, and low public control over environmental decision-making" (9).

ECONOMIC TRANSFORMATION AND THE ENVIRONMENT

Changes in the state of the natural environment and how environmental protection is practiced in Russia are closely related to the deep economic recession that occurred after the collapse of the Communist system, by some estimates a drop of 40% in gross domestic product (GDP), and the country's subsequent efforts to generate economic growth. Unfortunately, scholars in different subfields often do not have the expertise to bring together scientific analysis of environmental quality with possible explanatory variables from the economic sphere. Oldfield's book *Russian Nature: Exploring the Environmental Consequences of Societal Change* (24) is one of the few works that combines research on changing environmental quality with an overview of Russia's economic and legal transformation. Oldfield suggests that the study of Russia's environment in the post-Soviet period has been overly influenced by alternative understandings of the Russian environment as a disaster or as an element of the transition to democracy and a market economy, the former overly pessimistic and the latter overly linear and limited in its vision of Russia's potential future paths (24).

Determining causal links between economic decline and environmental quality in the 1990s is difficult, however, as both levels of economic activity and environmental pollution tend to be underreported in government statistics (5, 25, 26). The overall emission of air and water pollutants appears to have declined owing to severe economic recession, yet did not fall as much as may have been expected given the decline in industrial production. Lower levels of some pollutants also did not always result in great improvements in air and water quality, as discussed below. Crotty (26) argues that Russian government reports suggest that "economic transition has a pollution intensifying effect"—even as overall pollution decreased, pollution per unit of economic output increased.

There is general agreement that President Putin's administration has prioritized economic concerns over environmental protection and that the economy is increasingly dependent on the export of natural resources. Bradshaw (27) amasses a compelling body of statistics to show how reliant economically Russia has become on natural resources, including an Organisation for Economic Co-operation and Development analysis suggestion that 4% of Russia's annual 7% economic growth rate in the recent past is accounted for by the resource sector. Oil and gas exports have been the backbone of Russia's economic recovery. These exports have largely been drawn from "the most easily exploitable reservoirs and at the expense of balanced drilling on new sites" and thus are not sustainable without further exploration and investments (28). Because oil exploration and extraction are currently a major cause of wilderness fragmentation, the rate of fragmentation can be expected to increase as exploitation of new reserves becomes necessary to maintain supply. Other environmental pressures accompany the development of the petroleum sector. For example, by some estimates there are as many as two major oil and gas pipeline spills a day (29). Russian industries also use more energy than their counterparts in the West; in 2000 and 2001, Russia's GDP energy intensity measure was more than twice that of the United States (30). In part resulting from low-energy efficiency, Russia also emitted 3.8 times more greenhouse gases than the leading European countries per dollar of GDP (31).

Some analysts predict that Russia is beginning to suffer from a "resource curse," risking its economic development by relying on volatile commodities prices and its political stability by encouraging rent-seeking behavior by state officials. In addition, there is the question of whether resource revenue has been used effectively to diversify the economy or to support the manufacturing sector (27, 32, 33). Fears about the lack of sustainability of and environmental damage done by the current economic development model have led Russian environmental policy experts outside the government "to encourage the adoption of high and increasing values of natural resources and services" (34).

The Russian economy also is shifting from one in which consumer demand played only a superficial role as an economic driver to an increasingly consumption-based system. Rising income from oil exports has prompted a burst of consumer spending in Russia (35). Studies of new environmental threats related to the transition to a consumer society are a vital area for new research. For example, private car ownership more than doubled in the 1990s, and more than 50% of the atmospheric discharges in some of Russia's large cities now are caused by automobile exhaust (15). Household waste also has increased significantly, evidenced by the number of informal garbage dumps around cities and towns. Statistics show that municipal waste per capita in Russia more than doubled between 1980 and the late 1990s (although municipal waste remains less than half that of the United States on a per capita basis) (24).

THE STATE OF RUSSIA'S ENVIRONMENT

This section reviews scientific findings on Russian environmental quality in five indicator issue areas: water quality, the state of forests, effects of climate change, air quality, and

radiation. A survey of available research reveals significant logistical and political constraints to both the pursuit of such research and its broad dissemination. The result is a body of knowledge with irregular coverage, uneven depth, and in some cases questionable data quality. Producing nationwide environmental assessments for Russia is very difficult because of the country's vast size and highly variable levels of environmental degradation. As the largest country in the world with only the seventh largest population, Russia ranks 178th in population density with just over eight people per square kilometer. However, most people are concentrated in the urban-industrialized areas of western Russia where environmental degradation tends to be most severe, leaving extensive areas of eastern and northern Russia with relatively little human impact. Owing to this diluting effect, nationwide evaluations tend to rank Russia in categories of high environmental quality, although it contains some of the most locally degraded zones in the world. For example, the 2008 Environmental Performance Index (36) ranked Russia 28th out of 149 states. This heterogeneity in population distribution and environmental impact, as well as the great regional variation in ecosystem types, complicates data integration for countrywide analysis.

Another common challenge for scholarship on the state of Russia's natural environment is that independently collected data are extremely limited. As a result, much research is based on government data and reports that are not scientifically reviewed. Although still valuable, it is important to recognize several potential limitations and weaknesses in these sources of information. To partly explain why so little has been known about Russian air quality, Shahgedanova (37) points out that because pollution was portrayed as a "capitalist evil" the Soviet authorities were careful to control any information that might be interpreted as a sign of environmental degradation. Information on sensitive environmental subjects, such as air quality, was classified until the late 1980s, and access to academic papers was restricted (37). Records of fire damage have historically been underreported for political and economic reasons (38), as have radiation releases (39), and pollution related to military complexes (40). As a result, it is essential that more independent and scientifically reviewed data are provided and incorporated into future assessments of environmental quality.

A few scholars note that access to data from the Ministry of Natural Resources now may be improving (15). Although the amount of data may become more readily available, government influence on which data are released may continue. For example, Moiseenko et al. (41) points out that dissemination of information may still be limited to avoid local emigration from polluted zones where manpower is needed. The quality and consistency of data from the government also vary over time. Oldfield (24) suggests that information from government reports might reflect changes in accounting procedures, which are susceptible to economic and political influence. Past limitations on the circulation of academic work have also created barriers that are only slowly eroding. Older research is virtually impossible to acquire, a tremendous drawback for longitudinal studies, and only the most recent domestic research is being broadly disseminated.

Water Quality

As is the case with many natural resources in Russia, the state of water quality largely depends upon local conditions. In zones of heavy human impact, particular causes of poor water quality vary but are generally the result of overuse of water resources, inadequate water distribution and water treatment infrastructure, and proximity of polluting industry.

Russia has inherited a water system largely developed during the Soviet period, which favored extremely large water projects (42), resulting in significant alterations in water regimes and water quality. In many cases, reservoirs are simultaneously used for municipal and industrial consumption, and both treated and untreated water are released back (returned) with little concern for downstream use. In

heavy-use zones in the 1990s, estimates of the ratio of natural flow discharge to returned water were as low as 2:1 in some cases (43), levels generally inadequate for the maintenance of water quality.

The economic downturn and associated reduced demand after the collapse of the Soviet Union had a temporarily ameliorating influence on the volume of pollution discharge across the country. In a review of Russia's water resources, Oldfield (24) pointed out that during the economic downturn of the 1990s water demand dropped by approximately 27%, and polluted drainage discharge dropped by approximately 32%. However, government reports indicate water quality did not substantially improve, remaining below "accepted sanitary norms" in many areas in the late 1990s and early 2000s (24). Although there have been some instances of localized improvement (44), the lack of a positive trend in water quality is supported by independent studies (41, 45). Sources of water pollution are shifting, however. Reductions in both demand and polluted discharge were primarily the result of reduced industrial and agricultural needs; municipally polluted discharge remained relatively constant, resulting in its increased significance and currently accounting for almost two-thirds of the nation's total in 2005 (24). Municipal water treatment facilities are limited in extent, outdated, underfunded, and in a state of disrepair. Thus, there is no reason to expect improvements in the treatment of municipal water without major structural investments. Independent studies of municipal waste have been rare and limited in scope (46). High levels of *Giardia* cysts, likely from untreated human and animal waste runoff, have been locally detected in surface waters (46–48). Water treatment plants in the Moscow region are periodically contaminated with *Giardia* (47), and in cities, such as Saint Petersburg, residents commonly boil tap water before consumption. Serving as a strong bioindicator of the presence of parasitic contaminants, immunodeficient patients have been detected with high frequencies of the intestinal disease cryptosporidiosis in southern Russia (48).

Despite the increased significance of municipal wastewater, it is important to not underestimate the potential impacts of industrial pollution. Several studies record significant industrial releases of polychlorinated biphenyls (PCBs) (44, 49), heavy metals (45, 50–52), and radionuclides (39). In some cases, emissions are detectable hundreds of kilometers from the source (50, 52) or are so large that the affected water system has been described as "a severely polluted dead tributary" (51). Studies have found water pollution caused by atmospheric depositions to be relatively small in size and somewhat localized (45, 50, 53), although these studies tend to be limited in sample size and temporal scope primarily because of problems with accessing remote water bodies throughout the year. Atmospheric sources of water pollution can accumulate in water systems and have been detected in significant concentrations at downstream depositional and mixing zones (50).

The Volga River, the longest river and one of the most polluted in Europe, is a good example of the cumulative effects of overuse, poor wastewater treatment, and industrial proximity. Chuico et al. (49) describe industrial zones along the Volga where spills of pollutants, such as sulfuric acid, have overwhelmed the limited treatment facilities in place, resulting in ecological damage with pollutants currently detected in wastewater, sediments, and fish. Nadim et al. (54) point to the downstream impacts of polluted water from the Volga River in the ecological collapse of the Caspian Sea, which receives more than 85% of its freshwater from the Volga River. In addition to pollution, manmade barriers on the Volga, such as dams, block or limit fish migration and alter the habitat of nearly 70 native fish, as well as significantly influencing downstream water regimes and hydrographic patterns. When compounded by local contributions from oil pollution, the effects are severe. For example, human populations are being exposed to serious health risks. Also, pollution-weakened immune systems have resulted in the death of thousands of Caspian seals since 2000, and a combination of pollution

and poaching has led to the near extinction of sturgeon (54).

The State of Russia's Forests

Russia possesses the greatest area of forested land in the world, with over 808 million ha, representing 22% of the world total (55). Only 22% of Russia's forests are located within European Russia, and the remainder is situated in Siberia and the Russian Far East. In 1997, over 40% of Russian forests were categorized as relatively undisturbed and unfragmented "frontier forests" (56), although it appears that within the past decade the status of these forests has been changing rapidly. Using remote sensing and "ground-truthing," a 2002 follow-up study revised this estimate downward to 26% (57), whereas the UN Food and Agricultural Organization (FAO) estimated 32% for a similar category of "primary" forest in 2006 (55). Forest cover change in Russia is primarily due to logging and fire, and it is largely clustered near human settlements, transport routes, and natural resource extraction zones. For example, forest inventory maps show zones of concentrated forest degradation throughout densely populated western Russia and across eastern Russia along the Trans-Siberian railway corridor and in urban areas.

Forest ownership is entirely concentrated in public hands (58), and the state manages the territory primarily for forest production. Most estimates suggest that forest production dropped significantly following the collapse of the Soviet Union. In recent years, Russian forest products have made up approximately 5% of national gross export earnings, but statistics on forest extractions are difficult to verify when estimates of illegal production are as high as 65% of total forest exports (57). Pressure to increase extraction of Russian forest resources will continue as domestic and international demand for lumber grows. Russia will likely meet this demand as previously inaccessible areas are developed, with the rate of expansion particularly acute in the frontier areas of Siberia and the Russian Far East.

Since 2000, the FAO reports a marginal net decrease in total forest area in Russia of 0.01% and an increase in growing stock (55). This implies sustainable management of forest resources. Logging is not evenly distributed, and its impacts are concentrated in heavy extraction zones. The measure of total forest area has also been moderated by afforestation occurring in abandoned agricultural zones in the south (59), mostly involving the growth of deciduous forest and therefore not a substitute for the largely coniferous forests that are being logged. As a result, on a very large scale, forest use appears sustainable, but on a local or even regional basis, the numbers may conceal serious depletion of forest resources.

Several studies indicate that forest fire frequency in Russia has increased in the past 50 years as a result of global climate change (38) and human ignitions (59). According to Achard et al. (59), human ignitions are estimated to account for 87% of the fires in Siberia and exert a multiplier effect on increased fire risk, resulting from elevated spring and summer temperatures. Logging, mining, and oil extraction expand human access to forests and introduce ignition sources to remote areas (28). In addition, "the human impact on the forests through fires is higher owing to lack of control, ineffectual fire-management policies and new socioeconomic conditions in the region" (60).

Accurately monitoring forest change has been difficult, owing in part to the size and inaccessibility of forested areas. Soja et al. (38) found that Russian Federal Forest Service data and satellite-derived estimates of areas burned in eastern Russia differed by an average of 55%. One explanation given by the authors is that as much as 40% of the Russian Forest Fund is not monitored (38). The quality, accessibility, and compatibility of data available also make a national integration of systematic local observations problematic (61). In a thorough description of the national forest inventory system, which has been in service for over a hundred years, Kukuev et al. (62) describe it as containing what may be the largest collection of forest data in the world. Its use is limited,

Ground-truthing: verification on the ground of conditions on a site

however, by large amounts of data in nondigital form, incompatible digital formats, vast quantities of raw data, nonsynchronous data collection periods, and a system based on a Russian forest management tradition that does not match international norms. Because of resource and access limitations, remote sensing is growing in importance. International teams have been measuring large-scale variables such as land-use change (63), forest biomass (64), vegetation growing season anomalies (65), and forest fire emissions (66, 67). The use of these methods continues to develop, but this approach promises to significantly improve our knowledge base.

The Effects of Climate Change

Owing to its northern latitude, global climate change appears to be having an exaggerated effect in Russia (68), but specific effects and representation on the ground are not well understood (69). In a survey of the past 69 years, Groisman et al. found that northern Eurasia "was the region with the largest and steadiest increase of surface air temperature" (70). In montane southern Siberia, summer average temperatures increased as much as 0.5°C from 1960 to 1999 and 2°C in the last decade. Average winter temperatures increased up to 4.5°C from 1960 to 1999 and 3°C in the last decade (38). As a result, the duration of unfrozen ground has increased up to nine days, and the number of days with snow cover has decreased in the last 50 years (70). In other manifestations of creeping climate change, snow lines are migrating northward (71), glaciers are retreating (38), ice duration is decreasing, precipitation is increasing, and the period of water body summer stratification has increased (72). Changes in the timing and patterns of snow melt can alter local hydrology (68, 73), as well as have cumulative effects on the salinity levels, sea ice formation, global ocean circulation, and climate in the Arctic ocean, which receives 45% of it freshwater discharge from Siberia (74).

Observed biological impacts of warming include broad shifts in vegetation, such as upper treeline shifts into adjacent montane tundra (38); expansion of deciduous forests (73); and tundra conversion to forests and wetlands (69). Huttich et al. confirm that "changes in phenological dynamics between 1998 and 2005 caused by temperature anomalies are apparent for the whole boreal biome" (69). Examples of this change include earlier bud burst, extended growing season of up to three weeks, increased evaporative stress, increased ring growth, reduction in pine seed crop (75), changes in insect-plant dynamics, and changes in diatom community structure (72, 76). One of the most significant effects of surface warming has been a change in fire regime. Historically, eastern Russian forest has predominantly experienced surface fires, but from 1998 to 2002, high-severity crown fires were dominant (77), and seven of the last nine years have been extreme fire years in Siberia (38). The area burned in the 1990s was 29% greater than that in 1980s and 19% greater than the 47-year average (38).

The limnological characteristics of lakes in central Yakutia offer an example of the broad influences that climate change is having on the ground. Kumke et al. (68) point out that the effects of warming include the following:

- Increased water temperature and evaporation
- Increased length of ice-free season
- Stability of water stratification
- Aquatic organism and catchment vegetation changes
- Increased fire frequency
- Increased depth of active layer above permafrost affecting drainage regime and increasing volume of surface water
- Decreasing lake water levels

Limnological data for this vast region is limited, but with such broad impacts there is an urgent need for more research on lake physicochemical properties and biota across eastern Russia (68, 72).

Air Quality

As noted above, very little has been known about Russian air quality until recently, and

there is consensus among experts that the limited official estimates of pollutants that currently exist are systematically low compared to independent estimates (37). Owing to a combination of reduced industrial production and some improvements in cleaning methods at the point of origin, emissions of SO_2 and heavy metals appear to be on the decline regionally (37, 78, 79). However, it is difficult to make confident generalizations about air quality in Russia as a whole because coverage by monitoring stations is poor (40), independently generated data and peer-reviewed studies are limited, and scientists must rely heavily on government reports with the inherent limitations discussed earlier. For example, according to Ryaboshapko et al. (40) government statistics do not include emissions from some military enterprises, and small municipal and domestic sources are excluded. This is problematic as the authors' models suggest that most SO_2 deposition fluxes over Russia originate from domestic sources. The necessity for better information on air pollution is highlighted by the fact that as many as 6% of urban deaths (approximately 88,000 people annually) may be associated with particulate matter emissions alone (80).

In one of the first studies of its kind, Kuokka et al. (81) measured the chemical composition of aerosol particles on a transect across the entire country. Using the Trans-Siberian railway as a moving experimental platform, they found that the air was "heavily polluted between Moscow and roughly 4000 km east of it, as well as in the eastern part of the route close to Vladivostok." Across a vast expanse of Siberia and the Russian Far East measured chemical concentrations were low except in zones downwind of forest fires. In the remote regions of eastern Russia, forest fires are the major contributor of air pollution, and smoke plumes can extend thousands of miles, reaching as far as Korea and the Yellow Sea, but their specific impacts are largely unknown (82).

In Russia, there are several large industrial complexes that have been established in remote and otherwise lightly developed northern regions. Relative to scholarship on other Russian regions, a high number of peer-reviewed studies on air pollution from these complexes is available. Proximity to Russia's western border and the concern of neighboring countries may be factors behind this relative abundance of research. With an array of metallurgical complexes in these regions, air pollution has been intense with heavy environmental impacts resulting in "industrial deserts" (83). Primary pollutants include SO_2, NO_x, and heavy metals. Although local impacts around these complexes, and around similar entities in other areas, may be severe, regional impacts appear limited (53, 79, 83, 84). For example, heavy metal particulates appear to be deposited near their sources (83), limiting their spread, and problems of acidification of nearby water bodies tend to be neutralized by a combination of the emission of basic particles from industry (53, 83) as well as by natural buffering of water bodies, which act as sinks for these pollutants (78, 79).

Industrial desert: an area of extensive environmental degradation owing to industrial activity

Radiation

Since the late 1940s, Russia has had a poor record of radioactive releases into the environment. Original sources of radiation have included military and municipal nuclear power generation, weapons facilities, research facilities, explosive tests, waste storage facilities, mining, and processing plants. In general, any information on the subject has been highly restricted, but the Chernobyl accident of 1986 represented a watershed in public awareness and international concern about radioactive contamination. As a result, radiation is one of the more closely monitored environmental pollutants, but access to data is limited because radiation is classified as an issue of national security and because the Ministry of Defense is involved in the measurement process (85). In extreme instances, independent researchers investigating radioactive contamination have found themselves in prison. In a thorough review of the national monitoring metadata, Vakulovskii et al. (85) describes a collection system that results in data-rich annual reports. Yet as is the case in other national reporting

systems in Russia, the data are maintained in various forms, ranging from handwritten journals to electronic data banks, which limit broad analysis and independent review of the reported results, even for those scholars who gain access.

In their review, Makhon'ko & Kim (86) describe radionuclide contamination dynamics in air, soil, and water across the USSR and Russia and suggest that near ground and atmospheric fallout peaked in 1963. Since then, measured radiation levels have declined steadily, with the exception of 1986 when the explosion at the Chernobyl nuclear power plant, in what is now Ukraine, resulted in a temporary peak comparable with 1963 levels. Currently, the primary contributors of radionuclides to the air and water are outflows of accumulated residue in the soils. Although radioactive inputs may be declining, existing contamination persists owing to the substances' extended period of physical decay. Travnikova et al. found that, on the Kola Peninsula, "samples of vegetation and natural food products . . . indicate a very slow decrease in contamination levels during the last decade" (87).

Radioactive hot spots across Russia are the result of both acute accidental releases and long-term routine releases (39, 88). The Mayak Production Association, a weapons-grade plutonium processing facility in the Chelyabinsk region, offers a well-studied case of long-term routine releases. At various points between 1949 and the early 1960s, radioactive effluents were released directly into the air and into the Techa River, spreading across floodplains with spring floods. High levels of radionuclides are still detected in river fish, waterfowl, and poultry, as well as in milk and meat from cattle raised in the floodplains (88, 89), and impacts on human health, such as thyroid abnormalities, have been observed (90). Efforts have been made at the national and local levels to clean up existing contamination and limit further releases. However, although the river basin may be undergoing a process of natural deactivation, there are large stores of contaminants settled in reservoirs and waste storage facilities that pose a continuing risk as future contamination sources (88, 91). In other regions, scientists and environmentalists have expressed concern about contamination from spent nuclear fuel from submarines in the Northern and Pacific Fleets (92). For example, members of the Bellona Foundation (93) charge that there are approximately 100 tons of spent nuclear fuel from the Northern Fleet that have not been reprocessed.

RUSSIAN CITIZENS AND THE ENVIRONMENT

In principle, Russians possess strong environmental rights to address these and other environmental problems. The 1993 Constitution of the Russian Federation endows each citizen with "the right to a favorable environment, reliable information about its condition and to compensation for the damage caused to his or her health or property by ecological violations" (93a, Article 42). Public opinion polls illustrate consistently high levels of environmental concern. A 1993 poll indicated that 88% of Russians rated environmental quality at the national level as bad or fairly bad, and 62% thought that the environment presented a very serious problem. However, only 9% of respondents believed that the environment was the most important problem facing the country (94). According to Russia's Public Opinion Foundation, between 2001 and 2007, the number of respondents who believed that environmental quality was declining remained fairly stable at 60% to 65% of respondents (95). The areas of greatest public concern during that period were harmful effects from industrial activity and water quality.

In many societies, citizens may favor environmental protection, but they are less likely to support it if they see it as having high economic cost. DeBardeleben & Heuckroth (96) demonstrate that in the early 1990s Russians were more likely to see environmental protection as compatible with economic progress than were respondents in Western countries. In a more recent article, Whitefield (97) investigates Russians' willingness to make trade-offs between economic development and

environmental protection and concurs that in the early 1990s Russians exhibited a relatively high level of support for environmental protection in spite of economic costs, but he shows that this support declined steadily in the 1990s. Adopting a "supply-side" hypothesis of environmental concern, Whitefield points to the inability of environmental interest groups to shape the public's understanding of environmental problems and mobilize citizens, concluding, "It is not that Russians are more concerned about the economy and less about the environment. Rather, they are less able to connect their environmental concerns to their economic and other concerns" (97). Tynkkynen's analysis (98) of green nongovernmental organizations (NGOs) in Saint Petersburg also suggests that environmentalists need to develop more effective framing strategies to engage the public.

Many citizens appear to be worried about the link between environmental quality and public health, a highly contested and causally complex question in Russia, as elsewhere. The case for an environmentally related health catastrophe in Russia was made most strongly in Feshbach & Friendly's *Ecocide in the USSR: Health and Nature Under Siege* (99), published in 1992, which recounted a litany of health problems in the Soviet Union's highly industrialized cities. In 1999, 51% of Russian respondents expected environmental problems to affect the health of their children and grandchildren "a great deal" (96). According to a 2003 UN *Human Development Report*, health problems resulting from environmental pollution in Russia cost the state 6.3% of GDP on average (100). Russia's newest Green Party, formed in 2005 and headed by former presidential adviser Yablokov, has made the link between health and the environment a centerpiece of its political platform (101), although it is not yet clear whether that will improve its electoral prospects.

Although overall concern for the environment has remained relatively stable in the post-Soviet period, the level of environmental activism has fluctuated, rising dramatically in the late 1980s and early 1990s, during Gorbachev's reforms, and declining to a relatively low level in the current period. The environmental movement of the mid-1980s gained steam owing to a number of factors, including the 1986 Chernobyl nuclear accident, new access to information about the environment (102), and more liberal laws on association (103). The green movement became politically significant, forcing the cancellation of 60 nuclear power projects by 1991 (102). The perestroika-era environmental movement, unprecedented in its mass character, also attracted many individuals who saw environmental protests as a vehicle for voicing their opposition to the regime. Dawson's (103) comparison of antinuclear movements in Soviet republics notes that protests often had a strong nationalist undercurrent and characterizes this phenomenon as "movement surrogacy."

Environmental mobilization has declined in the post-Soviet period. For nationalists, their primary goal was achieved through the independence of former Soviet republics. Economic recession, individuals' need to focus on subsistence issues, and concern with keeping industrial enterprises open all contributed to the decline in activism, as did an optimism that the new regime would devote more attention to environmental protection. Mobilization in the small town of Kirishi in northwest Russia mirrors national trends. Tsepilova (104), who has conducted research on environmental mobilization in the town for almost two decades, argues that Kirishi's local movement was prompted by public perceptions of declining community health resulting from biochemical plant emissions and by frustration with an unresponsive local government. In the 1990s, however, in response to some improvement in local environmental policies, combined with economic instability, the movement lessened in strength, although based on survey evidence residents of Kirishi remain more likely to protest than citizens elsewhere.

Many contemporary analyses of environmental activism focus on the late 1980s as the emergence of Russia's environmental

movement, but nature conservation advocacy, led primarily by scientists, has deep roots in the Soviet period (105, 106). A number of current environmental leaders were drawn from scientific institutes or the student-based *Druzhina* green movement, which started at major Soviet universities in the 1960s (107). During the 1990s, environmental activists founded hundreds of NGOs across Russia. Mirovitskaya (102) asserts that by 1992 the green movement included more than 840 NGOs in the Russian Federation. The number of environmental organizations continued to grow in the mid-1990s. These groups include branches of international organizations, such as Greenpeace and the World Wildlife Fund, and a number of indigenous organizations working on issues ranging from poaching to environmental education. The environmental movement has been analyzed in several ways: the issues organizations address (108), their ideological orientation (109), or their relationships to other state and societal actors (101). Membership in these organizations tends to be low. On the basis of data from the World Values Survey at the end of the 1990s, membership in environmental organizations averaged 5.2% across the 56 countries surveyed, but the comparable numbers for Russia were 1.7% in 1990 and 0.7% in 1999 (110). Protests on environmental issues still occur, but they are relatively uncommon, usually involve members of environmental organizations such as Greenpeace-Russia, and rarely draw in members of the general public.

Russian environmentalists have had a difficult time linking the state and society in what is seen as the typical role for civil society organizations (111, 112). There are a number of domestic obstacles to environmental activism, and these problems may have been exacerbated by some organizations' reliance on foreign funding. Domestically, environmentalists find it difficult to gain access to basic information on the environment, to participate in policy making, and to receive an impartial hearing by the courts. Laws guaranteeing public access to environmental policy making often do have concrete mechanisms to enable participation in practice. For example, NGOs are allowed to submit environmental reviews on new industrial projects, but they have to gain access to information often classified as confidential and finance the work themselves (20, 23). Problems of secrecy are particularly acute in Russia's former closed cities, generally sites of military importance or scientific research (113–115). The state actively discourages environmental mobilization in the present period, disbanding even very small demonstrations and using inspections of tax and registration documents to harass organizations. Activism is also discouraged by the fate of environmental whistle-blowers such as Aleksandr Nikitin and Grigorii Pasko, who faced charges of treason, long court battles, and periods of imprisonment for publishing information that they argue was part of the public record. Yanitsky notes that in contrast to environmentalists' early success, "today state and local administrations cope successfully with the movement's challenges by using tactics of preemption, cooptation, and the organization of counter-movements" (116).

Environmentalists remain among the few groups in society willing to critique the government for its lack of transparency, democracy, and accountability. Green parties of varying ideological positions have competed in elections at all levels but have yet to succeed in gaining federal-level representation. Yet environmental organizations' reliance on foreign funding to carry out their projects has offered ammunition to state officials, who charge that their activities are anti-Russian and could be characterized as espionage. The government's accusations may have shaped the public's view of green NGOs. Crotty's analysis of the environmental movement in Samara describes public skepticism and suspicion in regard to environmental advocacy groups (19). In fact, foreign funding, although essential to the survival and growth of many groups, is blamed for a host of ills within the green movement, including fragmentation and weak ties between the movement and the public. Powell (117) argues that aid from Western foundations to green NGOs has done little to resolve Russia's environmental

problems because of the weakness of the post-Soviet state and the connection between environmental and economic issues. Considering the question of how Western states can best assist Russia in improving environmental protection, Bell (18) focuses on building public trust, creating more flexible and realistic laws and enforcement techniques, and identifying alternative sources of financial support. International programs have helped some environmentalists make progress in certain areas, however. For example, forest certification programs provided an opportunity for Russian NGOs to bring local residents into decision making about environmental governance and the use of local resources (118). Environmentalists appear to be most effective at this kind of public engagement when they do not try to create new organizations but draw upon preexisting community institutions to bring broader networks of people into public deliberation on environmental issues (119).

RUSSIA AND INTERNATIONAL ENVIRONMENTAL COOPERATION

As the primary successor state to the Soviet Union, the Russian Federation took on all of the USSR's treaty obligations. In the 1990s, Russia committed itself to more than 30 bilateral environmental agreements and more than 25 regional environmental regimes (120). Yet the literature on Russia's participation in international environmental regimes reveals limitations to Russia's role as an international environmental partner. First, Russia's willingness and ability to act as a partner in environmental problem solving has been constrained by the progressive weakening of its environmental protection agencies. Second, Russia has been most likely to cooperate at the international level when there is a nonenvironmental incentive, such as economic or security benefits or technology transfer. Finally, Russia has been able to comply with many environmental agreements owing to lower levels of industrial production in the 1990s, but it has not yet demonstrated a commitment to effective implementation of these agreements.

The Soviet Union, and subsequently Russia, frequently used participation in international agreements as a means of achieving other goals, both political and economic. For example, during the 1970s, the USSR participated in the Convention on Long-Range Transboundary Air Pollution (LRTAP) as part of a broader effort to promote détente between East and West (121). In the late 1980s, President Gorbachev similarly supported international environmental agreements on air pollution, degradation of the Baltic Sea, and nuclear safety in order to lessen hostility during the perestroika reforms (122). In fact, the late 1980s represent the high point of international environmental cooperation between Russia and the West. Later, in the 1990s, Darst (122) argues that Russia's attitude toward international environmental cooperation was one of "environmental blackmail" in which Russia sought payment from Western partners for good environmental behavior.

In fact, paying for environmental improvements in Russia often appears to be a relatively cost-effective measure for Western states to achieve environmental gains. Because of the Soviet legacy of environmental degradation and the range of ecosystems types, Russia offers tremendous scope for improving and conserving the environment on a global scale. In the Baltic Sea area, neighboring states were able to achieve substantial improvements in environmental quality through investing in environmental protection in Russia (122). The Kyoto Protocol, which Russia ratified in 2004 after a long period of delay, offers Russia the potential for economic gain and its partners the opportunity for environmental benefits. Russia will be able to sell greenhouse gas emissions credits and acquire investment through joint implementation projects. Russian ratification of Kyoto also occurred almost simultaneously with the European Union's decision to support Russia's application for World Trade Organization membership, a fact which many observers argue is not coincidental (123, 124). At the same time, Russia's inefficient industrial sector

Hot air: a reduction in greenhouse gas emissions as an inadvertent outcome of an event such as an economic recession

presents tremendous opportunities to reduce greenhouse gas emissions at a relatively low cost as compared to the cost of incremental reduction in European economies.

Given Russia's commitment to a number of international environmental regimes, scholarly attention increasingly has shifted to the implementation of these accords. In the Soviet period, once the government made a decision, it was likely to be implemented. In the post-Soviet period, the government's capacity to implement international agreements has declined owing to many of the same challenges that hinder environmental protection domestically, i.e., weak environmental protection agencies, decentralization, corruption, and so forth (125). Hønnelund & Jørgenson's review of Russia's international commitments cautions, "Successful implementation of international commitments is contingent upon both the will and the ability of states to influence activities at the domestic level" (125). Stokke (126) details how domestic factors constrained action on nuclear waste dumping at sea even after the federal government decided to address the problem. The dumping issue also is an example of an environmental problem that strongly implicates the military, requiring Western partners to engage Russia's "power ministries" and complicating negotiations with the military culture of secrecy (127).

On many environmental measures, Russia has been able to achieve "compliance without implementation" because of the sharp drop in some kinds of pollution after the country's severe economic recession in the 1990s. For example, Darst credits Russia's success at meeting its LRTAP air quality commitments in the 1990s to the steep reduction in industrial activity, referring to Russia's strategy as "how to succeed in 'greenness' without really trying" (122). In addition, Russia technically has met its obligations to the Kyoto Protocol by "hot air" through the sharp decline in greenhouse gas emissions during the industrial collapse of the 1990s, but its choice of how actively to participate in Kyoto's flexible mechanisms is important for the success of the agreement as a whole (123). Victor and his collaborators (128) are pessimistic about whether international regimes have actually influenced Russian behavior, pointing out that the poor implementation of international environmental agreements in Russia has not been unexpected, but they argue future prospects for Russia's participation may be more promising if economic actors are able to develop a longer-term perspective and if more players are able to participate in environmental protection.

A significant amount of foreign assistance money has flowed to the Russian state to facilitate environmental protection. There is some debate as to whether these funds have been spent effectively. Technology transfers and assistance with monitoring have received praise, but many scholars argue that domestic commitment to environmental protection matters more than the amount or form of assistance from the West. There is some agreement that environmental partnerships involving Russia have been most effective when the interests of the donor and recipient countries match (18, 122, 129) and particularly when Russia's economic and security concerns are addressed as part of the environmental negotiations (127, 130). Examples of successful cooperation cited in the literature include funding from the UN Development Programme and the Global Environment Facility to Russia to support the partial implementation of the Convention on Biodiversity (131), Western financing for waste water treatment in the Baltics (132), and model forest demonstration projects for promoting sustainable and internationally certified forestry (118). Economic issues, such as a lack of clear property rights and a lack of transparency in costs, can undermine foreign assistance programs, and legal differences between domestic law and international agreements have also presented challenges in combating problems, such as illegal timber harvesting and wildlife poaching.

There is another type of international engagement that likely is as consequential for the environment as the array in international agreements, but has been much less studied: Russia's

integration into international markets and its particular role as a natural resource provider. Andonova and her collaborators consider the potential for rising levels of international trade to induce a race to the bottom in the post-communist region and conclude, "During the 1990s, trade openness undermined a key element of environmental policy by reducing governments' ability to collect environmental taxes and support environmental investments" (133). Russia currently is the largest exporter of natural gas and the second largest exporter of oil (134). International demand for oil, natural gas, timber, and a range of mineral resources is likely to increase, with potentially dire implications for Russia's natural environment. However, market incentives can also be used for environmental protection. For example, forest certification has become relatively common in European Russia because of its proximity to European markets with their greater demand for certified products and the greater penetration of European firms into the Russian timber sector. Certification has not fared as well in the Far East, where demand for timber comes mostly from the Chinese market (118).

CONCLUSION

Scholars continue to debate how to characterize Russia's environment given the extreme variability in environmental quality and diverse threats to the environment across the federation. Activists and scholars also struggle to evaluate trajectories of change, which range from reduction in some major air and water pollutants, to abandoned farmland reverting to forest, to an increasing number of commitments to international environmental agreements, to the transition to a consumer society (with the rapid development of suburban land, increasing car ownership, and growing municipal waste) (8). Russia's economic recovery entails potential benefits and risks for the environment, and it offers an essential subject for future research. These debates are set against the backdrop of an increasingly closed Russian political system, with more constraints on freedoms of the press and association. Some have argued that there is utility in seeing Russia's environmental problems as a threat to national security (120), while others hope that the concept of sustainable development will offer a path to more effective environmental protection. Still others question who will carry out environmental research and advocacy in Russia in the future. In his most recent book, the Russian environmental sociologist Oleg Yanitsky (135) expresses concern that the next generation of Russian environmental leaders is disappearing in part owing to the erosion of institutions of higher education and research, which fostered them in the past.

Environmental scientists desperately need more data and the academic freedom to discuss their findings. Social scientists need to undertake more comparative work—regionally and cross-nationally—to better understand the real state of the Russian environment and to avoid both of the extremes embodied by the complacency and the catastrophic predictions of the past. Research on Russia's environment can be characterized as having irregular coverage, uneven depth, and in some cases questionable data quality. However, there are several promising trends. Expanded international and domestic investment in research, as well as improved technologies, such as remote sensing, may help overcome some logistic hurdles inherent in studying a country as large as Russia. An increase in the availability of independently collected data, scientifically reviewed reports, and conversion to international accounting and reporting standards may improve confidence in results. Broader dissemination and access to Russian scholarship, resulting from new online catalogs of Russian publications, means that more data are available and may facilitate collaboration between Russian and non-Russian scholars. Russia's international environmental commitments also require national reports, which may provide leverage for coalitions, inside and outside Russia, that advocate environmental protection. What remains to be seen is whether these trends will continue in spite of the current drift away from political pluralism.

SUMMARY POINTS

1. The state of Russia's environment and its environmental management are of global significance because Russia is a repository of high levels of biodiversity and is a natural resource provider to the world markets.
2. The Soviet legacy continues to influence Russia's environment and its environmental protection practices.
3. Russia experienced temporary improvement on some measures of environmental quality as a result of the economic recession of the 1990s.
4. Russia relies heavily on natural resource extraction for its economic development, contributing to problems such as overexploitation of air and water resources, fragmentation of wilderness, and declining forests as a result of logging and fire.
5. Russia's state agencies of environmental protection have been progressively weakened since the mid-1990s.
6. Russian citizens appear to be highly concerned about environment, but environmental activism is relatively low, possibly because of political and economic obstacles.
7. Russia has been willing to sign a number of international agreements, but its motivations are not always related to environmental protection, contributing to the problem of weak implementation.
8. Scholarship on the Russian environment is limited by challenges of data acquisition and freedom of information.

FUTURE ISSUES

1. Will the Ministry of Natural Resources be an effective agent of environmental protection?
2. How quickly will Russia's consumer economy develop and what will its effects be on the environment?
3. Will Russia continue to rely heavily on the natural resource sector for economic development and how will that affect the environment, particularly in the Far East and North?
4. How will Russia's changing political system, including the new presidential administration as of March 2008 and the dominance of the United Russia party, influence environmental activism?
5. Will Russia meet its international environmental commitments? In particular, will it actively participate in the flexible mechanisms of the Kyoto Protocol or rely on compliance made easy by hot air?
6. How will continued global warming affect the Russian environment?
7. Will Russia's scientific institutions recover? How will environmental science develop in Russia in the future? Will access to data improve?

DISCLOSURE STATEMENT

The authors are not aware of any biases that might be perceived as affecting the objectivity of this review.

ACKNOWLEDGMENT

Laura Henry would like to thank the Fulbright Scholar program and the Eurasian Program of the Social Science Research Council. The authors are also grateful to Oleg Yanitsky, Maria Tysiachniouk, Greg Goldsmith and Anthony Falzone.

LITERATURE CITED

1. DeBardeleben J. 1985. *The Environment and Marxism-Leninism: The Soviet and East German Experience*. Boulder, CO: Westview
2. Pryde PR. 1972. *Conservation in the Soviet Union*. New York: Cambridge Univ. Press
3. Jancar B. 1987. *Environmental Management in the Soviet Union and Yugoslavia*. Durham, NC: Duke Univ. Press
4. Ziegler CE. 1987. *Environmental Policy in the USSR*. Amherst: Univ. Mass. Press
5. Peterson DJ. 1993. *Troubled Lands: The Legacy of Soviet Environmental Destruction*. Boulder, CO: Westview
6. Knorre A. 2001. The rise and fall of environmental protection as a national security issue. In *Russia's Fate Through Russian Eyes: Voices of a New Generation*, ed. H Isham, pp. 284–95. Boulder, CO: Westview
7. Blacksmith Inst. 2006. *Annual report 2006*. **http://www.blacksmithinstitute.org/docs/2006ar.pdf**
8. Ecological consequences of the disintegration of the USSR. 2004. *Soc. Sci.* 35(3):111–24
9. Kotov V, Nikitina E. 2002. *Reorganisation of environmental policy in Russia: the decade of success and failures in implementation and perspective quests*. Fond. Eni Enrico Mattei Note di Lavoro Ser. **http://www.feem.it/NR/rdonlyres/59A79BBF-DE58-4819-BC3F-C0FE71384402/346/5702.pdf**
10. Pryde PR. 1991. *Environmental Management in the Soviet Union*. Cambridge, UK: Cambridge Univ. Press
11. Bond AR, Sagers MJ. 1992. Some observations on the Russian Federation environmental protection law. *Post-Sov. Geogr.* 33(7):463–74
12. Oldfield JD, Shaw DJB. 2002. Revisiting sustainable development: Russian cultural and scientific traditions and the concept of sustainable development. *Area* 34(4):391–400
13. Glushenkova HI. 1999. Environmental administrative change in Russia in the 1990s. *Environ. Polit.* 8(2):157–64
14. Peterson DJ, Bielke EK. 2001. The reorganization of Russia's environmental bureaucracy: implications and prospects. *Post-Sov. Geogr. Econ.* 42(1):65–67
15. ZumBrunnen C, Trumbull N. 2003. Environmental policy challenges. In *Russia's Policy Challenges: Security, Stability, and Development*, ed. SK Wegren, pp. 250–75. Armonk, NY: Sharpe
16. Dawson JI, Darst RG. 2005. Russia's proposal for a global nuclear waste repository: safe, secure, and environmentally just? *Environment* 47(4):10–21

16a. Bigg C. 2005. Russia: after Chinese toxic spill, environmentalists raise concerns about ecological policy. *RadioFreeEurope/RadioLiberty*, Nov. 30. **http://www.rferl.org/featuresarticle/2005/11/fcbafcc7-e9eb-49e6-b047-d4efdad9119c.html**

17. Yanitsky ON. 2000b. Sustainability and risk: the case of Russia. *Innov.: Eur. J. Soc. Sci. Res.* 13(3):265–77
18. Bell RG. 2000. Building trust: laying the foundation for environmental regulation in the former Soviet bloc. *Environment* 42(2):20–32
19. Crotty J. 2003. The reorganization of Russia's environmental bureaucracy: regional response to federal changes. *Eurasian Geogr. Econ.* 44(6):462–75
20. Cherp O. 2000. Environmental impact assessment in the Russian Federation. In *Environmental Assessment in Countries in Transition*, ed. E Bellinger, N Lee, C George, A Paduret, pp. 114–25. Budapest: Cent. Eur. Univ. Press

21. Kjeldsen S. 2000. Financing of environmental protection in Russia: the role of charges. *Post-Sov. Geogr. Econ.* 41(1):48–62
22. Larin V, Mnatsakanian R, Chestin I, Shvarts E. 2003. *Okhrana Prirody Rossii: Ot Gorbacheva do Putina*. Moscow: World Wildl. Fund (WWF). **http://www.wwf.ru/resources/publ/book/73/**
23. Ostergren DM, Jacques P. 2002. A political economy of Russian nature conservation policy: why scientists have taken a back seat. *Glob. Environ. Polit.* 2(4):102–24
24. Oldfield JD. 2005. *Russian Nature: Exploring the Environmental Consequences of Societal Change*. Burlington, VT: Ashgate
25. Oldfield JD. 2000. Structural economic change and the natural environment in the Russian Federation. *Post-Communist Econ.* 12(1):77–90
26. Crotty J. 2002. Economic transition and pollution control in the Russian Federation: beyond pollution intensification? *Eur. Asia Stud.* 54(2):299–316
27. Bradshaw M. 2006. Observations on the geographical dimensions of Russia's resource abundance. *Eurasian Geogr. Econ.* 47(6):724–46
28. Dienes L. 2004. Observations on the problematic potential of Russian oil and the complexities of Siberia. *Eurasian Geogr. Econ.* 45:319–45
29. Pelley J. 2001. Will drilling for oil disrupt the Arctic National Wildlife Refuge? *Environ. Sci. Technol.* 35(11):240–47
30. Volkonskii VA, Kuzovkin AI. 2006. Energy intensity and energy efficiency of the Russian economy: an analysis and forecast. *Stud. Russ. Econ. Dev.* 17(1):34–40
31. Yulkin MA. 2005. Russia and the Kyoto Protocol: how to meet the challenges and not to miss the challenges. Tallinn, Estonia: Environ. Invest. Cent. **http://www.eel.nl/documents/cms_eel_105_1_Kyoto%20Article.pdf**
32. Gaddy CG, Ickes BW. 1998. Russia's virtual economy. *Foreign Aff.* 77(5):53–67
33. Kuboniwa M, Tabata S, Ustinova N. 2005. How large is the oil and gas sector of Russia? A research report. *Eurasian Geogr. Econ.* 46(1):68–76
34. Zakharov VM, ed. 1999. *Priorities for Russia's National Environmental Policy*. Moscow: Cent. Russ. Environ. Policy
35. Tabata S. 2006. Observations on the influence of high oil prices on Russia's GDP growth. *Eurasian Geogr. Econ.* 47(1):95–111
36. Esty DC, Levy MA, Kim CH, de Sherbinin A, Srebotnjak T, Mara V. 2008. *Environmental performance index: Russia*. New Haven: Yale Cent. Environ. Law Policy. **http://epi.yale.edu/Russia**
37. Shahgedanova M. 2003. Air pollution. In *The Physical Geography of Northern Eurasia*, ed. M Shahgedanova, pp. 476–96. Oxford: Oxford Univ. Press
38. Soja AJ, Tchebakova NM, French NHF, Flannigan MD, Shugart HH, et al. 2007. Climate-induced boreal forest change: predictions versus current observations. *Glob. Planet. Change* 56:274–96
39. Lind OC, Oughton DH, Salbu B, Skipperud L, Sickel MA, et al. 2006. Transport of low Pu-240/Pu-239 atom ratio plutonium-species in the Ob and Yenisey Rivers to the Kara Sea. *Earth Planet. Sci. Lett.* 251:33–43
40. Ryaboshapko A, Gallardo L, Kjellstrom E, Gromov S, Paramonov S, et al. 1998. Balances of oxidized sulfur and nitrogen over the former Soviet Union territory. *Atmos. Environ.* 32:647–58
41. Moiseenko TI, Voinov AA, Megorsky VV, Gashkina NA, Kudriavtseva LP, et al. 2006. Ecosystem and human health assessment to define environmental management strategies: the case of long-term human impacts on an Arctic lake. *Sci. Total Environ.* 369:1–20
42. Klubnikin K, Annett C, Cherkasova M, Shishin M, Fotieva I. 2000. The sacred and the scientific: traditional ecological knowledge in Siberian river conservation. *Ecol. Appl.* 10:1296–306
43. Koronkevich N. 2003. Rivers, lakes, inland seas, and wetlands. In *The Physical Geography of Northern Eurasia*, ed. M Shahgedanova, pp. 122–148. Oxford: Oxford Univ. Press
44. Kostamo A, Viljanen M, Pellinen J, Kukkonen J. 2000. EOX and organochlorine compounds in fish and ringed seal samples from Lake Ladoga, Russia. *Chemosphere* 41:1733–1740
45. Allen-Gil SM, Ford J, Lasorsa BK, Monetti M, Vlasova T, Landers DH. 2003. Heavy metal contamination in the Taimyr Peninsula, Siberian Arctic. *Sci. Total Environ.* 301:119–38

46. Egorov A, Paulauskis J, Petrova L, Tereschenko A, Drizhd N, Ford T. 2002. Contamination of water supplies with *Cryptosporidium parvum* and *Giardia lamblia* and diarrheal illness in selected Russian cities. *Int. J. Hyg. Environ. Health* 205:281–89
47. Larin VE, Kashkarova VP. 2002. Occurence of *Giardia* cysts and *Cryptosporidium* oocysts in surface and treated waste waters of the Moscow region, Russia. In *Giardia: the Cosmopolitan Parasite*, ed. BE Olson, ME Olson, PM Wallis, pp. 261–67. Wallingford, UK: Cab Int.
48. Karanis P, Sotiriadou I, Kartashev V, Kourenti C, Tsvetkova N, Stojanova K. 2006. Occurrence of *Giardia* and *Cryptosporidium* in water supplies of Russia and Bulgaria. *Environ. Res.* 102:260–71
49. Chuiko GM, Tillitt DE, Zajicek JL, Flerov BA, Stepanova VM, et al. 2007. Chemical contamination of the Rybinsk Reservoir, northwest Russia: relationship between liver polychlorinated biphenyls (PCB) content and health indicators in bream (*Abramis brama*). *Chemosphere* 67:527–36
50. Coquery M, Cossa D, Martin JM. 1995. The distribution of dissolved and particulate mercury in three Siberian estuaries and adjacent Arctic coastal waters. *Water Air Soil Pollut.* 80:653–64
51. Leslie HA, Pavluk TI, de Vaate AB, Kraak MHS. 1999. Triad assessment of the impact of chromium contamination on benthic macroinvertebrates in the Chusovaya River (Urals, Russia). *Arch. Environ. Contam. Toxicol.* 37:182–89
52. Gordeev VV, Rachold V, Vlasova IE. 2004. Geochemical behaviour of major and trace elements in suspended particulate material of the Irtysh River, the main tributary of the Ob River, Siberia. *Appl. Geochem.* 19:593–610
53. Walker TR, Young SD, Crittenden PD, Zhang H. 2003. Anthropogenic metal enrichment of snow and soil in north-eastern European Russia. *Environ. Pollut.* 121:11–21
54. Nadim F, Bagtzoglou AC, Iranmahboob J. 2006. Management of coastal areas in the Caspian Sea region: environmental issues and political challenges. *Coast. Manag.* 34:153–65
55. UN Food Agric. Organ. (FAO). 2007. *State of the World's Forests*. Rome: UN FAO
56. Bryant D, Nielsen D, Tangley L. 1997. *The Last Frontier Forests: Ecosystems and Economies on the Edge*. Washington, DC: World Res. Inst.
57. Newell J. 2004. *The Russian Far East*. McKinleyville, CA: Daniel & Daniel/Friends Earth-Jpn
58. Wulder MA, Campbell C, White JC, Flannigan M, Campbell ID. 2007. National circumstances in the international circumboreal community. *For. Chron.* 83:539–56
59. Achard F, Mollicone D, Stibig HJ, Aksenov D, Laestadius L, et al. 2006. Areas of rapid forest-cover change in boreal Eurasia. *For. Ecol. Manag.* 237:322–34
60. Mollicone D, Eva HD, Achard F. 2006. Ecology: human role in Russian wild fires. *Nature* 440:436–37
61. Kinnunen J, Maltamo M, Paivinen R. 2007. Standing volume estimates of forests in Russia: How accurate is the published data? *Forestry* 80:53–64
62. Kukuev YA, Krankina ON, Harmon ME. 1997. The forest inventory system in Russia: a wealth of data for Western researchers. *J. For.* 95:15–20
63. Bergen KM, Conard SG, Houghton RA, Kasischke ES, Kharuk VI, et al. 2003. NASA and Russian scientists observe land-cover and land-use change and carbon in Russian forests. *J. For.* 101:34–41
64. Krankina ON, Houghton RA, Harmon ME, Hogg EH, Butman D, et al. 2005. Effects of climate, disturbance, and species on forest biomass across Russia. *Can. J. For. Res.* 35:2281–93
65. Balzter H, Gerard F, George C, Weedon G, Grey W, et al. 2007. Coupling of vegetation growing season anomalies and fire activity with hemispheric and regional-scale climate patterns in central and east Siberia. *J. Climate* 20:3713–29
66. Isaev AS, Korovin GN, Bartalev SA, Ershov DV, Janetos A, et al. 2002. Using remote sensing to assess Russian forest fire carbon emissions. *Clim. Change* 55:235–49
67. Conard SG, Sukhinin AI, Stocks BJ, Cahoon DR, Davidenko EP, Ivanova GA. 2002. Determining effects of area burned and fire severity on carbon cycling and emissions in Siberia. *Clim. Change* 55:197–211
68. Kumke T, Ksenofontova M, Pestryakova L, Nazarova L, Hubberten HW. 2007. Limnological characteristics of lakes in the lowlands of central Yakutia, Russia. *J. Limnol.* 66:40–53
69. Huttich C, Herold M, Schmullius C, Egorov V, Bartalev SA. 2007. Indicators of northern Eurasia's land-cover change trends from SPOT-VEGETATION time-series analysis 1998–2005. *Int. J. Remote Sens.* 28:4199–206

70. Groisman PY, Knight RW, Razuvaev VN, Bulygina ON, Karl TR. 2006. State of the ground: climatology and changes during the past 69 years over northern Eurasia for a rarely used measure of snow cover and frozen land. *J. Climate* 19:4933–55
71. Iijima Y, Masuda K, Ohata T. 2007. Snow disappearance in eastern Siberia and its relationship to atmospheric influences. *Int. J. Climatol.* 27:169–77
72. Mackay AW, Ryves DB, Morley DW, Jewson DH, Rioual P. 2006. Assessing the vulnerability of endemic diatom species in Lake Baikal to predicted future climate change: a multivariate approach. *Glob. Change Biol.* 12:2297–315
73. Oltchev A, Cermak J, Gurtz J, Tishenko A, Kiely G, et al. 2002. The response of the water fluxes of the boreal forest region at the Volga's source area to climatic and land-use changes. *Phys. Chem. Earth* 27:675–90
74. Ye HC, Yang DQ, Zhang TJ, Zhang XB, Ladochy S, Ellison M. 2004. The impact of climatic conditions on seasonal river discharges in Siberia. *J. Hydrometeorol.* 5:286–95
75. Ovchinnikova NF, Ermolenko PM. 2004. Long-term forest vegetation inventories in West Sayan mountains. *World Res. Rev.*
76. Solovieva N, Jones VJ, Nazarova L, Brooks SJ, Birks HJB, et al. 2005. Palaeolimnological evidence for recent climatic change in lakes from the northern Urals, Arctic Russia. *J. Paleolimnol.* 33:463–82
77. Soja AJ, Cofer WR, Shugart HH, Sukhinin AI, Stackhouse PW, et al. 2004. Estimating fire emissions and disparities in boreal Siberia (1998–2002). *J. Geophys. Res. Atmos.* 109:D14S06
78. Lappalainen A, Tammi J, Puro-Tahvanainen A. 2007. The effects of nickel smelters on water quality and littoral fish species composition in small watercourses in the border area of Finland, Norway and Russia. *Boreal Environ. Res.* 12:455–66
79. Solovieva N, Jones VJ, Appleby PG, Kondratenko BM. 2002. Extent, environmental impact and long-term trends in atmospheric contamination in the Usa basin of east-European Russian Arctic. *Water Air Soil Pollut.* 139:237–60
80. Golub A. 2007. Cost of air pollution in Russia. *Epidemiology* 18:S89–90
81. Kuokka S, Teinila K, Saarnio K, Aurela M, Sillanpaa M, et al. 2007. Using a moving measurement platform for determining the chemical composition of atmospheric aerosols between Moscow and Vladivostok. *Atmos. Chem. Phys.* 7:4793–805
82. Lee KH, Kim JE, Kim YJ, Kim J, von Hoyningen-Huene W. 2005. Impact of the smoke aerosol from Russian forest fires on the atmospheric environment over Korea during May 2003. *Atmos. Environ.* 39:85–99
83. Reimann C, Banks D, de Caritat P. 2000. Impacts of airborne contamination on regional soil and water quality: the Kola Peninsula, Russia. *Environ. Sci. Technol.* 34:2727–32
84. Walker TR, Crittenden PD, Young SD, Prystina T. 2006. An assessment of pollution impacts due to the oil and gas industries in the Pechora basin, north-eastern European Russia. *Ecol. Indic.* 6:369–87
85. Vakulovskii SM, Kozova EG, Kim VM, Yakhryushin VN. 2006. Metadata on the radioactive contamination of environmental objects on the territories of Russia and the USSR. *At. Energy* 101:602–5
86. Makhon'ko KP, Kim VM. 2002. Dynamics of air, soil, and water contamination by technogenic radionuclides on the territory of the USSR and Russia in 1954–2000. *At. Energy* 92:421–29
87. Travnikova IG, Shutov VN, Bruk GY, Balonov MI, Skuterud L, et al. 2002. Assessment of current exposure levels in different population groups of the Kola Peninsula. *J. Environ. Radioact.* 60:235–48
88. Akleyev AV, Kostyuchenko VA, Peremyslova LM, Baturin VA, Popova IY. 2000. Radioecological impacts of the Techa River contamination. *Health Phys.* 79:36–47
89. Shutov VN, Travnikova IG, Bruk GY, Golikov VY, Balonov MI, et al. 2002. Current contamination by Cs-137 and Sr-90 of the inhabited part of the Techa River basin in the Urals. *J. Environ. Radioact.* 61:91–109
90. Mushkacheva G, Rabinovich E, Privalov V, Povolotskaya S, Shorokhova V, et al. 2006. Thyroid abnormalities associated with protracted childhood exposure to I-131 from atmospheric emissions from the Mayak weapons facility in Russia. *Radiat. Res.* 166:715–22
91. Standring WJF, Oughton DH, Salbu B. 2002. Potential remobilization of Cs-137, Co-60, Tc-99 and Sr-90 from contaminated Mayak sediments river and estuary environments. *Environ. Sci. Technol.* 36:2330–37

92. Bogatov SA, Vysotskii VL, Sarkisov AA, Pologikh BG, Sivintsev YV, Nikitin VS. 2006. Analysis of the radioactive contamination of the environment due to decommissioned objects of the nuclear-powered fleet in northwestern Russia. *At. Energy* 101:485–93
93. Bøhmer N, Nikitin A, Kurdik I, Nilsen T, McGovern MH, Zolotov A. 2001. *The Artic Nuclear Challenge*, Bellona Rep. Vol. 3. Oslo: Bellona Found.
93a. Russ. Fed. 1993. *Constitution of the Russian Federation*. **http://www.constitution.ru/**
94. Dunlap RE, Gallup GH Jr, Gallup AM. 1993. *Health of the Planet*. Princeton, NJ: Gallup Int. Inst.
95. Fond Obshchestvennoe Mnenie. 2007. *Ekologiia v Rossii: otsenka situatsii*. **http://bd.fom.ru/report/map/d073222**
96. DeBardeleben J, Heuckroth K. 2001. Public attitudes and ecological modernization in Russia. In *The Struggle for Russian Environmental Policy*, ed. I Massa, V Tynkkynen, pp. 49–76. Helsinki: Kikimora
97. Whitefield S. 2003. Russian mass attitudes toward the environment, 1993–2001. *Post-Sov. Aff.* 19(2):95–113
98. Tynkkynen N. 2006. Action frames of environmental organisations in post-Soviet St. Petersburg. *Environ. Polit.* 15(4):639–49
99. Feshbach M, Friendly A Jr. 1992. *Ecocide in the USSR: Health and Nature Under Siege*. New York: Basic Books
100. UN Dev. Programme (UNDP). 2003. *Human Development Report: Russian Federation, 2002/2003*. Moscow: UNDP
101. Henry LA. 2006. Shaping social activism in post-Soviet Russia: leadership, organizational diversity, and innovation. *Post-Sov. Aff.* 22(2):99–124
102. Mirovitskaya N. 1998. The environmental movement in the former Soviet Union. In *Environment and Society in Eastern Europe*, ed. A Tickle, I Welsh, pp. 30–66. Harlow, UK: Longman
103. Dawson JI. 1996. *Eco-Nationalism Anti-Nuclear Activism and National Identity in Russia, Lithuania, and Ukraine*. Durham: Duke Univ. Press
104. Tsepilova O. 2007. Forging change in a contaminated Russian city: a longitudinal view of Kirishi. See Ref. 136, pp. 31–46
105. Weiner DR. 1988. *Models of Nature: Ecology, Conservation, and Cultural Revolution in Soviet Russia*. Bloomington: Indiana Univ. Press
106. Weiner DR. 1999. *A Little Corner of Freedom: Russian Nature Protection from Stalin to Gorbachev*. Berkeley: Univ. Calif. Press
107. Shvarts EA, Prochozova I. 1992. Soviet greens: Who are they? In *Environmental Action in Eastern Europe: Responses to Crisis*, ed. B Jancar-Webster, pp. 176–91. Armonk, NY: Sharpe
108. Tysiachniouk M, Bolotova A. 1999. Environmental activism in the St. Petersburg region. In *Towards a Sustainable Future: Environmental Activism in Russia and the United States*, ed. M Tysiachniouk, GW McCarthy, pp. 191–209. St. Petersburg: Inst. Chem., St. Petersburg Univ.
109. Yanitsky O. 1996. *Ekologicheskoe Dvizhenie Rossii: Kriticheskii Analiz*. Moscow: Russ. Acad. Sci./Inst. Sociol.
110. Dalton RJ. 2005. The greening of the globe? Cross-national levels of environmental group membership. *Environ. Polit.* 14(4):441–59
111. Henry LA. 2006. Russian environmentalists in civil society. In *Russian Civil Society: A Critical Assessment*, ed. A Evans, LA Henry, LM Sundstrom, pp. 211–28. Armonk, NY: Sharpe
112. Crotty J. 2006. Reshaping the hourglass? The environmental movement and civil society development in the Russian Federation. *Organ. Stud.* 27(9):1319–38
113. Kutepova N, Tsepilova O. 2007. Closed city, open disaster. See Ref. 136, pp. 147–64
114. Mironova N, Tysiachniouk M, Reisman J. 2007. The most contaminated place on Earth: community response to long-term radiological disaster in Russia's southern Urals. See Ref. 136, pp. 165–83
115. Garb P, Komarova G. 1999. A history of environmental activism in Chelyabinsk. In *Critical Masses: Citizens, Nuclear Weapons Production, and Environmental Destruction in the United States and Russia*, ed. RJ Dalton, P Garb, NP Lovrich, JM Whiteley, pp. 165–92. Cambridge, MA: MIT Press
116. Yanitsky O. 2000. *Russian Greens in a Risk Society: A Structural Analysis*. Helsinki: Kikimora
117. Powell L. 2002. Western and Russian environmental NGOs: a greener Russia? In *The Power and Limits of NGOs*, ed. SE Mendelson, JK Glenn, pp. 126–51. New York: Columbia Univ. Press

118. Tysiachniouk M. 2006. Forest certification in Russia. In *Confronting Sustainability: Forest Certification in Developing and Transitioning Countries*, ed. B Cashore, F Gale, E Meidinger, D Newsom, pp. 261–95. New Haven: Yale School Environ. Stud.
119. Tysiachniouk M, Meidinger E. 2006. *Using forest certification to strengthen rural communities: cases from northwest Russia*. Buffalo Leg. Stud. Res. Pap. Ser. 2006–011
120. Funke O. 2005. Russian environmental security issues: competing frameworks for the future. *Int. J. Environ. Technol. Manag.* 5(2/3):246–75
121. Kotov V, Nikitina E. 1998. Implementation and effectiveness of the acid rain regime in Russia. See Ref. 128, pp. 519–47
122. Darst RG. 2001. *Smokestack Diplomacy: Cooperation and Conflict in East-West Environmental Politics*. Cambridge, MA: MIT Press
123. Henry LA, Sundstrom LM. 2007. Russia and the Kyoto Protocol: seeking an alignment of interests and image. *Glob. Environ. Polit.* 7(4):47–69
124. Korppoo A, Karas J, Grubb M, eds. 2006. *Russia and the Kyoto Protocol: Opportunities and Challenges*. London: Chatham House
125. Hønnelund G, Jørgenson A. 2003. Implementing international environmental agreements in Russia: lessons from fisheries management, nuclear safety and air pollution control. *Glob. Environ. Polit.* 3(1):72–98
126. Stokke OS. 1998. Nuclear dumping in Arctic seas: Russian implementation of the London Convention. See Ref. 128, pp. 475–517
127. Sawhill SG. 2000. Cleaning-up the Arctic's cold war legacy: nuclear waste and Arctic military environmental cooperation. *Coop. Confl.* 35(5):5–36
128. Victor DG, Raustiala K, Skolnikoff EB, eds. 1998. *The Implementation and Effectiveness of International Environmental Commitments*. Cambridge, MA: MIT Press
129. Roginko A. 1998. Domestic implementation of Baltic Sea pollution commitments in Russia and the Baltic states. See Ref. 128, pp. 575–637
130. Stokke OS. 2000. Subregional cooperation and the protection of the Arctic marine environment: the Barents Sea. In *Protecting the Polar Marine Environment: Law and Policy for Pollution Prevention*, ed D Vidas, pp. 124–48. Cambridge: Cambridge Univ. Press
131. Oldfield JD, Kouzmina A, Shaw DJB. 2003. Russia's involvement in the international environmental process: a research report. *Eurasian Geogr. Econ.* 44(2):157–68
132. Kotov V, Nikitina E. 1998. Regime and enterprise: Norilsk Nickel and transboundary air pollution. See Ref. 128, pp. 549–74
133. Andonova L, Mansfield ED, Milner HV. 2007. International trade and environmental policy in the postcommunist world. *Comp. Polit. Stud.* 40(7):782–807
134. Energy Inf. Adm. 2007. *Russia*. **http://www.eia.doe.gov/cabs/Russia/Background.html**
135. Yanitsky O. 2007. *Ekologicheskaia Kul'tura: Ocherki vzaimodeistviia nauki I praktiki*. Moscow: Nauka
136. Edelstein MR, Tysiachniouk M, Smirnova LV, eds. 2007. *Cultures of Contamination: Legacies of Pollution in Russia and the U.S.* Amsterdam: Elsevier