



The politics of Amazonian deforestation: environmental policy and climate change knowledge

Marko S. A. Monteiro,^{1*} Sonia Regina da Cal Seixas² and Simone Aparecida Vieira²

This article reviews literature on the science and politics of deforestation in the Amazon from 1970 until today, focusing on their shifting meanings and the increasing relevance of climate change knowledge to their understanding and management. Since large-scale colonization of the region began in the 1970s, the debate on deforestation has been crucial in disputes involving science, development, and the environment. In the last decade, the issue of climate change has become more present in the science, politics, and policies related to deforestation in the Amazon. This debate has helped shift discussions on both the environmental and the development agenda for the region. Although there is a broad agreement that the Amazon is being increasingly integrated into global fluxes of knowledge, goods, and people, not all view this process under the same light. The review concludes that scientific views help condition the development of changing policy arrangements aimed at curbing deforestation, and the incorporation of climate change knowledge is an important aspect of the dynamics of environmental policies in the region. © 2014 John Wiley & Sons, Ltd.

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THE SCIENCE AND POLITICS OF MANAGING THE AMAZON REGION

The Amazon is the world's last forest of continental dimensions, which helps explain the enormous interest it generates in groups that want to either develop and extract its riches or preserve its unmatched biodiversity and natural conditions.^{1,2} Such groups have clashed through decades over how to best manage the region's resources.^{3–5} These conflicts have become more intense since the 1970s, when the era of 'modern deforestation' began.^{6–8} Such

conflicts have often been mediated by scientific debates, but the questions being asked and the relationship such science has had with policy seem to be shifting. In recent years, the issue of climate change has increasingly occupied a more central role in scientific discourses on deforestation, and become more integrated into policy efforts aimed at controlling deforestation and managing the forest's resources.

Climate change is not, however, the only issue under dispute concerning deforestation in the region: analyzing the longstanding debates on what constitutes desirable development,^{4,1,6,9–16} as well as of the complex issue of biodiversity (which will not be explored in this review), is crucial in understanding the politics and policies directed at deforestation in the Amazon. Positions more favorable to current policies (including some in favor of controversial, large scale infrastructural projects) argue that, with all its problems, these initiatives have integrated the Amazon into local and global economic, social and

*Correspondence to: markosy@ige.unicamp.br

¹Science and Technology Policy Department, State University of Campinas (UNICAMP), Campinas, SP, Brazil

²Center for Environmental Studies and Research (NEPAM) and PhD Program on Environment and Society, State University of Campinas (UNICAMP), Campinas, SP, Brazil

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informational flows, creating new economic, and environmental opportunities for the region.^{4,11,17} Critics argue that exogenous development models^{18,19} ignore and destroy local knowledge, commodify the forest,²⁰ and suppress potential alternative (local) modes of living. They argue that this imposes relationships with the environment that ultimately reproduce predatory practices inherited from the industrial revolution.^{21–23}

As the Amazon's human settlements have become consolidated,^{4,24} and as public opinion (both inside and outside the Amazon region) has demanded deeper commitments to preservation and mitigation efforts, conflicts around deforestation involving scientists, environmental groups, and political institutions have shaped a complex set of regulations, technologies, and discourses that have succeeded, to some extent, in slowing the pace of forest destruction.^{25,26} At the same time, the renewed economic force of countries in the Amazon region, in particular that of Brazil, has put pressure on the forests and reinvigorated calls for the exploration of the region's potential for hydroelectric power (i.e., the Belo Monte hydroelectric power plant), petroleum and gas, agriculture (i.e., soy and other export crops), and cattle production.²⁶ Authors point to a continuing ambiguity in policies toward the region: initiatives to protect local ecosystems are developed in parallel to ever-larger infrastructure investments^{4,17,27} aimed at guaranteeing future economic growth locally and regionally.

This review will analyze how these scientific and social dynamics enable and constrain conflicts, policies, and perceptions around deforestation. The narrative of the Amazon as a crucial element of the world's climate has become more central to how the region is understood both inside and outside science, leading governments in the region to adopt legal frameworks on climate change that address deforestation^{28,29} (e.g., Brazil's National Policy on Climate Change). At the same time, disputes over how to best develop, protect, and colonize the region are becoming more visible as the region becomes a resource frontier.^{30–34}

The review will first address the origins of large-scale deforestation in the Amazon and its links to policies for development, discussing how and in what terms deforestation emerges as a problem in the region; then the scientific debates on deforestation will be explored, in order to show how research on climate change has acquired a growing relevance to the understanding of deforestation; lastly, the interface between science and policy in the region will be discussed, analyzing how changes in the scientific perception of deforestation may correlate with changing policy arrangements in the region.

THE EMERGENCE OF DEFORESTATION AS A PROBLEM IN THE AMAZON

Deforestation emerged as a problem through a complex interplay between science, activism, and policy, beginning in the 1960s and 1970s when massive colonization of the region started. The modern period of deforestation in the Amazon began in 1972, with the opening of the Trans-Amazonian highway and the ensuing influx of colonizers, who were given fiscal incentives by Brazil's government to develop agriculture and cattle in the region.^{16,35,36} These factors were strong inducers of deforestation in the 1970s and 1980s,^{8,37} raising concerns both inside and outside the region about the destruction of the forest.^{38–40} Accused of financing the burning of the Amazon, the World Bank and local governments in Brazil came under pressure from national and international public opinion.^{36,41} In 1991, government decree no. 153 suspended new incentives.⁴² Alongside land speculation, such incentives remained relevant to deforestation well until the end of the 1980s. These policies allowed for the formation of medium and large sized cattle farms, which today drive roughly 70% of Amazon deforestation.^{8,37}

Policies of this period in Brazil were framed under a national security doctrine, which sought to promote the colonization of the Amazon in order to avoid foreign interference^{13,36,43,44} or even a possible internationalization of the area.⁴⁵ This geopolitical frame helped direct many of the policies undertaken by Brazil's military regime^{46–48} (1964–1988). In this period, developing the Amazon became a central piece of the overall development strategy of the military governments,^{30,45,49,50} leading to conflicts over not just the destruction of the Amazon, but the violent migratory fluxes and the authoritarian way these projects were being developed and implemented.

Such rapid increase in the influx of immigrants and in deforestation rates during the 1970s and 1980s did not happen without resistance from local populations.²¹ Groups such as *ribeirinhos*,^b *seringueiros*,^c *quilombola*^d communities, and small farmers all fought in their own ways the advance of large scale farming, land grabbing, and authoritarian policies. These movements had many faces but their most visible and recognizable leadership was environmental activist Chico Mendes, who actively advocated for these groups until his assassination in December of 1988.⁵¹

The redemocratization of Brazil marked profound changes in environmental policy, driven by internal processes and external pressures.^{e,52} The

period saw a shift away from many of the policies of the military regime, which had since 1966 undertaken efforts to colonize the Amazon and integrate it to the rest of the country socially and economically.^{1,4,53} After a new Brazilian constitution was adopted in 1988, civilian and democratically elected officials began to implement policies to protect the Amazon biome and to open up dialog concerning international cooperation around environmental issues,⁵⁴ a politically sensitive issue even today.

As colonization of the region advanced, so did the international outcry to stop the destruction of the Amazon, which influenced the materialization of policies such as the Our Nature (Nossa Natureza) program (1988) created in Brazil during president José Sarney's term in office.^{8,53,55} In 1989 the Brazilian Institute of the Environment, Natural and Renewable Resources—IBAMA—was created, with the aim of acting as an environmental police, overseeing Brazil's environmental policies. In 1992 the Pilot Program for the Protection of Brazilian Tropical Forests—PP-G7—was launched, during the United Nations Conference on Environment and Development (UNCED), or Rio-92, involving Brazil and the G7 countries in the protection of local forests, of which the Amazon was the most relevant.⁵³ This program proposed, among other initiatives, ecological corridors in order to protect *in situ* the biological diversity of areas such as the Amazon, but such initiatives never composed a well-articulated overall policy for the region. Large scale, top-down projects of development such as *Avança Brasil*, for example, established by President Fernando Henrique Cardoso in the 2000s, proposed transport networks which cut across ecological corridors, illustrating the ambiguous nature of official policies for the Amazon.^{27,56,57}

International scientific cooperation in the Amazon also became stronger during the 1990s. This was stimulated, for example, by international science and technology agreements which were established by Brazilian institutions such as the Emilio Goeldi Museum and the National Institute of Amazon Research—INPA with North American and European institutions.⁵⁸ This sort of cooperation was not entirely new: German and American researchers had already been studying the Amazon in Brazil between 1960 and 1970,^{53,58} but the scale and relevance of international cooperation grew considerably after Rio-92.^{52,58} This culminated with the implementation of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA), one of the largest scientific cooperation efforts in the world.

Cooperation was also established through the action of NGOs created in the 1990s,^{13,17} which

developed engaged scientific research about deforestation (including Imazon,^f IPAM,^g ICV,^b among others). These NGOs have become crucial producers of scientific knowledge about deforestation, and have had great influence in the formulation of public policies for the Amazon region.^{4,52,54} Some activism, focused on promoting 'sustainable development'⁵⁹ in the region, has been critiqued for a vision of the forest as capital to be exploited,^{12,60} a position which is stronger among organizations based in the urban middle class.⁶¹ Besides producing scientific knowledge, these NGOs have also been critical in shaping how development is perceived and practiced, for example by criticizing multilateral banks,^{61,62} and links with international groups have also helped to make local activism much more visible worldwide.²¹

The interplay between scientific perceptions of deforestation, activism, and policy is thus a relevant feature of how deforestation emerged as a problem for science and for institutions involved in managing development and the environment. This interconnectivity is also important to the dynamics of deforestation science and politics in the 2000s, when the science of climate change emerges as a more relevant body of work.

DEFORESTATION SCIENCE AND CLIMATE CHANGE KNOWLEDGE

Scientific work on deforestation in the Amazon, although dating back at least to the 1970s, became more visible in the 1980s–1990s.⁴⁸ Debates around the rates of forest destruction, the first attempts to measure deforestation through remote sensing, and discussions on the role of paved roads and land use patterns as drivers of deforestation set the tone for discussions in the period. In the 2000s, however, the main focus gradually shifted to climate change. As we can see from the graphs below, a search in the Web of Knowledge database reveals that while scientific production focusing specifically on deforestation in the Amazon has not grown significantly from the 1990s until today (Figure 1), there is a very significant growth on works that correlate climate change with the Amazon (Figure 2) and with deforestation (Figure 3), especially after 2003.

A 1989 report on the Brazilian Amazon by the World Bank³⁹ is an important marker of the changing scientific perceptions about deforestation. The report, which argued for large-scale destruction of the Amazon based on remote sensing data, helped make visible the growing scientific debate on how fast deforestation was occurring and at what rate the forest would disappear.^{38,63}

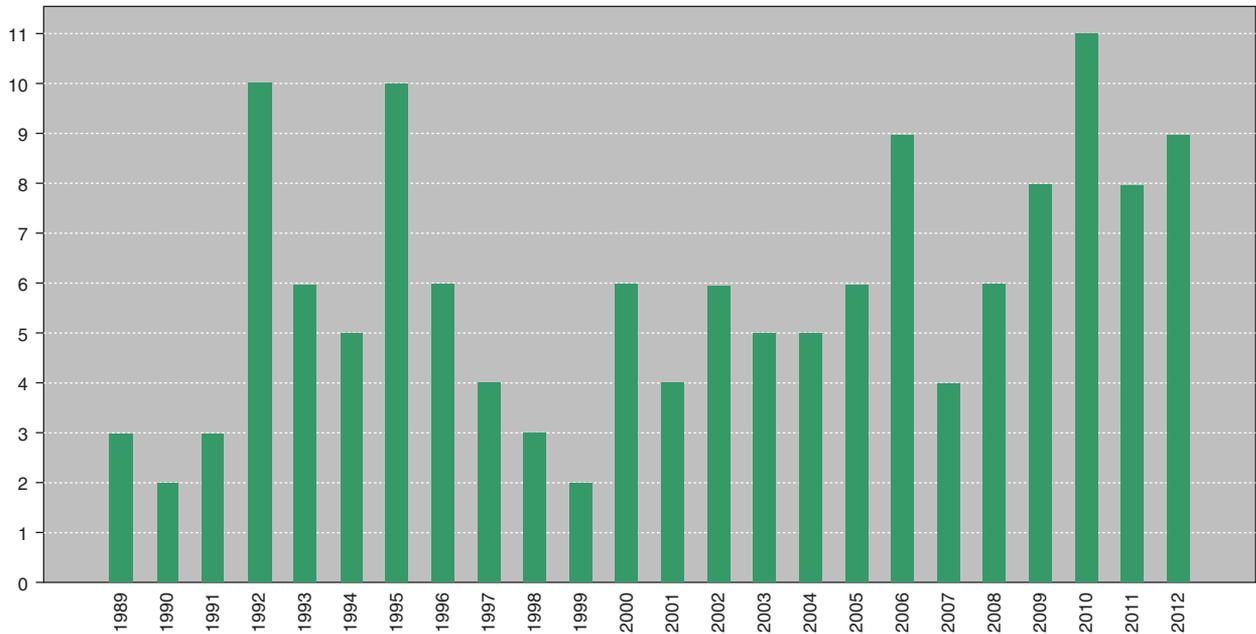


FIGURE 1 | Search of all articles published, with terms 'Amazon + deforestation' (Source: ISI).

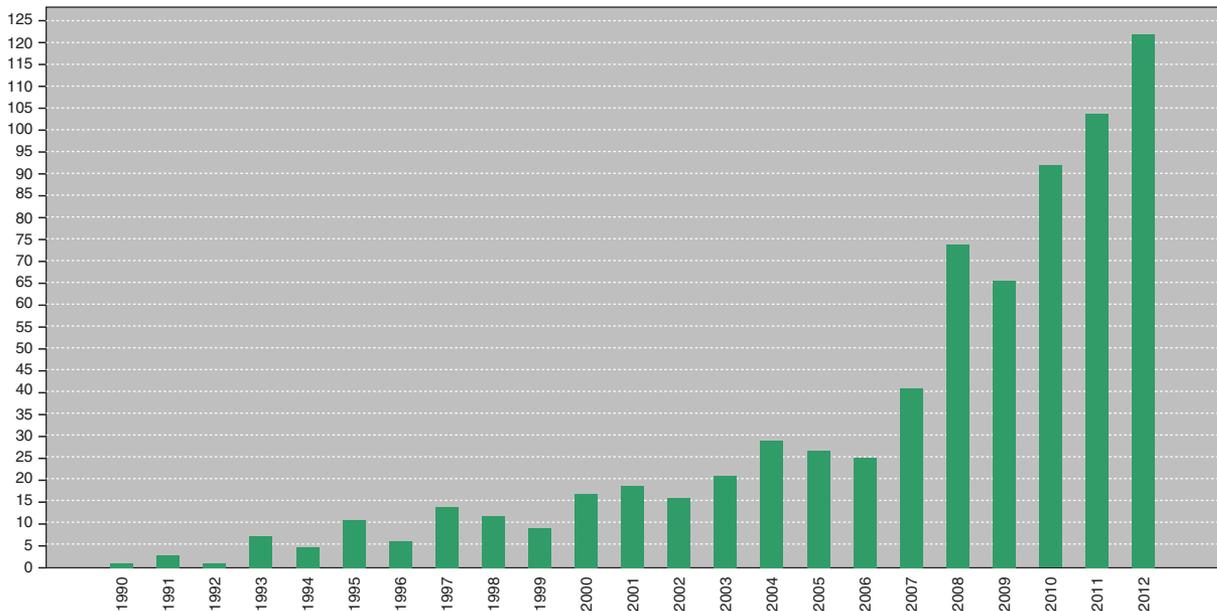


FIGURE 2 | All articles containing the terms 'climate change + Amazon' (Source: ISI).

While at this moment the tone of the public debates was more conservationist, scientists already debated the controversy over the forest's carbon balance^{63,64} and how deforestation was contributing to climate change. Earlier reports had called attention to the possibly exponential rate of deforestation, especially related to the building of roads in the region, calling into question the myth of the 'infinite forest' suggested by the earliest Brazil's National Institute of Space Research (INPE) data from 1978.³⁸ Later

empirical work has consistently found that paved roads are good predictors of deforestation.^{36,65–67}

Current research show the consolidation of some earlier frontier areas as productive regions for cattle and agriculture^{24,33}; the urbanization of the Amazonian population,^{14,68,69} and its inclusion in local, national and global fluxes of information, goods and persons.^{10,17,33,69} The region's population has grown to around 23 million, most of them living in Brazilian urban areas, and forest loss stands at around 16.3% of

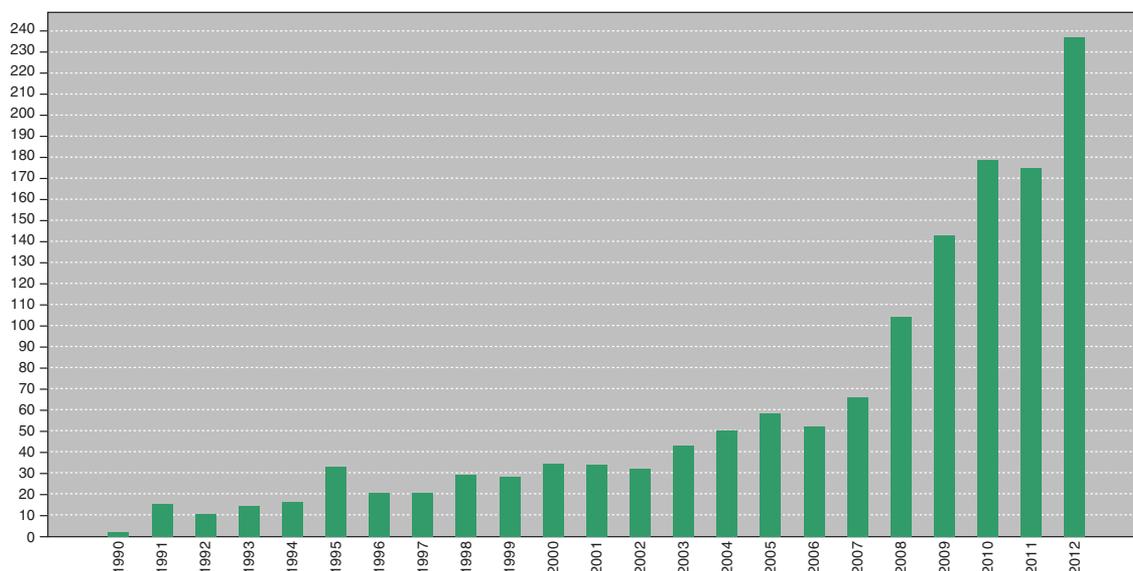


FIGURE 3 | All articles containing the terms 'climate change + deforestation' (Source: ISI).

its original area.^{24,70} The region's economy continues to grow as official policies drive down transportation costs (e.g., through road building, improvement of ports, etc.), improve sanitary conditions (e.g., control of foot-and-mouth disease helps the cattle industry) and make the region's commodities more competitive through monetary and trade reforms.^{24,27}

Studies also suggest that the drivers of Amazonian deforestation may be changing: transition to urban areas may indicate that population growth no longer accounts for the majority of land use change⁶⁸; at the same time, growing cattle and timber economies may be new drivers for the continuing destruction of the forest.^{15,34,68,71,72} The growing tenure security in the region, instead of mitigating deforestation once led by conflicts over ownership, may actually incentivize deforestation, as farmers feel more secure to expand investments in cattle pasture.⁶⁸ However, recent studies⁷³ have also suggested a decoupling between growing agricultural outputs and deforestation, which indicates that recent policies may be helping reduce agricultural production's role as a driver of forest destruction. This shows the success of measures to curb deforestation associated with crop expansion, although it is unclear that these benefits can withstand increasing demand for agricultural products.⁷³

Although the debate around possible impacts of deforestation of tropical forests on climate started in the 1970s,⁷⁴ the theme gained relevance in the 1980s and 1990s. Seen as a system in equilibrium, the Amazon was increasingly perceived as a relevant part of world climate due to its role in the

hydrological system.⁷⁵ Theories began to predict a probable substitution of forests by savanna-like vegetation through complex and interrelated phenomena including deforestation, climate change, and the forest's moisture balance, reinforced by data produced by climate models.^{76–79} Savannization theories helped frame the importance of deforestation as part of larger processes of global climate change, as deforestation began to be perceived as part of complex, large-scale phenomena, which work synergistically to influence the globe's climate patterns.

One version of the savannization theory was outlined in the 1990s by meteorologist Carlos Nobre and collaborators^{78–80} based on a coupled atmosphere–biosphere numerical model. The forest's role in moisture circulation was central to their argument, and helped shed light on how regional climates are affected by land use practices. In the past, rainfall was thought to be unconnected to the underlying vegetation. This view changed in the 1970s and 1980s, after which the presence of vegetation came to be seen as an influence in regional climates through evapotranspiration, which is now understood an important source of rainfall in the Amazon.⁷⁸ Numerical models suggest that vegetation loss leads to increased surface temperatures and loss in rainfall, which in turn can cause further losses in rainforests and a breakdown in the equilibrium between these parts.^{76,79,81}

However, this interpretation is controversial and not all data or analyzes point to evapotranspiration as a source of rainfall. Positions on the issue depend on how one views the role of deforestation in climate change. According to some scientists,⁷⁹ the

forest–atmosphere interaction in the Amazon helps preserve the forest, due to the forest’s low albedo, high rates of evapotranspiration and nutrient recycling, large roughness to the surface airflow and the large water-holding capacity of soils. These results emerge from climate models that simulate the replacement of forest with degraded pasture. Simulation data suggest an increase in surface temperature and decrease in rainfall in such a scenario. The resulting climate change and change in rainfall could further decrease the forest and increase the savannah type vegetation, effectively moving the forest-savannah boundary north of its current position.

Climate models have thus become central tools in the understanding of the role of deforestation in global climate, although they are not used without critique. Many believe that the best way to assess and reflect on future scenarios of climate change is to rely on such models. But these simulations have two basic sources of uncertainty: (1) the future trajectory of emissions of greenhouse gases (GHG) is uncertain because they depend on human decisions; (2) models are imperfect representations of reality.⁸² One way to mitigate that uncertainty is to rely on several different models.⁸³

Among other findings, these models point to the Amazon as a hot spot of vulnerability to climate change, including both potential biodiversity loss and socioeconomic impacts.⁸⁴ Vulnerability would emerge from a synergy between climate change (creating warmer and dryer climates in the region), less availability of rains and deforestation.⁸⁵ This could lead, according to some, to a ‘tipping point’, a threshold that when crossed could lead to irreversible changes in the biome.^{77,86} A new equilibrium could be established by savanna-like or other fire-resistant vegetation, but many agree that this would lead to the loss of crucial environmental services, such as its condition as a carbon pool and possibly a carbon sink,⁸⁷ with ensuing and hard to predict effects on global climate.⁸⁶ Other relevant services include the Amazon’s role as a regulator of water balance and river flows, a modulator of regional climate patterns and even ameliorator for infectious diseases.³²

Such a tipping point could possibly be averted by deliberately avoiding deforestation,⁸⁸ which has become an important focus of environmental policies for the region. Concepts such as environmental services, many connected to the dynamics of climate change, are increasingly relevant to environmental and development policies in the Amazon, indicating a growing presence of the issue in science and in policy.

EMBEDDING CLIMATE CHANGE KNOWLEDGE IN POLICIES AIMED AT DEFORESTATION

Aside from influencing how deforestation was perceived scientifically, climate change knowledge has been increasingly incorporated into environmental policies in the Brazilian Amazon. The country’s National Policy on Climate Change—PNMCⁱ (Política Nacional sobre Mudanças do Clima), for example, sets specific goals to reduce emissions of GHG and regulates how those goals are to be achieved.⁸⁹ It is closely related to Brazil’s international commitments since Rio-92, i.e., the signing of the United Nations Framework Convention on Climate Change (UNFCCC). Since the failed COP 15 discussions in Copenhagen, and COP 16 in Cancun, Brazil has committed itself to voluntary emission reductions between 36.1% and 38.9%, as ratified in the PNMC.²⁸

Brazil’s policies on climate change are closely tied to the monitoring and mitigation of deforestation, as most of the country’s emissions derive from land use change. While globally this sector accounts for 17% of global GHG emissions, in Brazil it represents 61%, with deforestation of the Amazon contributing to the lion’s share of this number.⁹⁰ Since the 1990s, the average area annually deforested in the Amazon has been 16,000 km², with peaks in 1995 (29,000 km²), and between 2003 and 2004 (~26,000 km²). These values have decreased over time⁹¹: about 6500 km² were deforested in 2010. According to recent studies,⁹² the annual emission rate for 1999–2006 was of 0.26 ± 0.08 Tg C yr⁻¹ from deforestation and 0.11 ± 0.02 Tg C yr⁻¹ from degradation, totaling 0.37 Tg C yr⁻¹ (1 Tg=1012 g). From 2006, there was an emission increase, arising from the Inter-oceanic Highway paving and new timber concessions logging and gold mining (deforestation emissions— 0.42 ± 0.21 Tg C yr⁻¹ and degradation emissions— 0.21 ± 0.11 Tg C yr⁻¹).

In the 2000s, the relevance of initiatives to stop deforestation was further recognized in Brazil through the creation of the Fundo Amazônia.^j This fund receives donations that go toward non-refundable investments in actions of prevention, monitoring, and curbing of deforestation, promoting the sustainable use and conservation of the Amazon. The fund has a technical committee—CTFA, whose responsibility is to verify measurements made by the Environment Ministry relating to reductions of carbon emissions caused by deforestation.⁹³ Areas eligible for support include management of public forests and protected areas; environmental control,

monitoring, and inspection; sustainable forest management; economic activities from the sustainable use of forests; Ecological-Economic Zoning (EEZ), land-use planning, and land title regularization; conservation and sustainable use of biodiversity; and recovery of deforested areas.⁹⁴

Although the Amazon's role in regulating world climate became increasingly established at the turn of the 21st century,⁸¹ deforestation and land use change persisted. Brazil's INPE alerted in 2003 that an expressive growth in deforestation had happened between 2001 and 2002.⁹⁵ This led Brazil's government to create the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon—PPCDAM^k (Plano de Prevenção e Controle do Desmatamento na Amazônia) in 2004.⁹³ This policy focused on the so-called 'arch of deforestation'.⁵⁵ It came only two years after the launching of the Program for Protected Areas in the Amazon—ARPA^l (Programa de Áreas Protegidas da Amazônia), which has as its goal to protect 563,000 km² by 2016. Studies show that this initiative has been efficient in curbing deforestation in protected areas.^{96,97} Also relevant was the introduction of Resolution 3.545 by Brazil's Central Bank in 2008, which limits the concession of rural credit to properties that can prove compliance to environmental legislation. This has reduced credit concession to farmers by 2.9 billion Brazilian Reals, and studies show this may have helped cause a 15% reduction in deforestation⁹⁸ (2700 km² in the period).

Other initiatives in the period include the United Nations Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD), the United Nations' mechanism to compensate countries that successfully reduce carbon emissions deriving from forest degradation.²⁶ Initially this mechanism was conceived so that developing countries could effectively participate in global efforts to reduce emission of GHGs, a proposal initially referred to as 'compensated reduction'.⁹⁹

Presently, signatory countries to the UNFCCC are negotiating the establishment of policies and incentives for countries to adopt one or more of the following actions aimed at mitigating climate change: (1) reducing emissions from deforestation and forest degradation; (2) increasing forest carbon stocks; (3) sustainable forest management, and (4) forest conservation. According to what was established in the last UNFCCC decisions, REDD+ should also take into account the implementation of co-benefits, such as conservation of biodiversity and the reduction of poverty.^{100,101}

According to the Center for International Forestry Research^m (CIFOR), there were between 20 and 30 REDD projects under development in Brazil in 2010, with many state-level legislation being enacted aimed at regulating REDD+. The state of Amazonas, for example, approved the State Policy on Climate Change, Environmental Conservation and Sustainable Development (Política Estadual sobre Mudanças Climáticas, Conservação Ambiental e Desenvolvimento Sustentável—Law 3.135/2007). This law created the Bolsa Floresta Program, which pays traditional communities for environmental services. Other states enacted similar legislation: the state of Acre created in 2010 the State System for Incentives to Environmental Services (Sistema Estadual de Incentivos a Serviços Ambientais—SISA; State law 2.308/2010); the state of Mato Grosso created in January 2013 the State System for Reducing Emissions from Deforestation and Forest Degradation (Sistema Estadual de Redução das Emissões por Desmatamento e Degradação Florestal—Law 9.87/2013).

Although understanding the exact mechanisms to reduce deforestation in the Amazon is a technical and scientific challenge, it has been suggested that conservation policies have helped to avoid around half of expected deforestation in the absence of those policies.^{98,102} A World Bank study entitled Justice for Forests¹⁰³ reinforces this perception, suggesting that institutional fragility and impunity favors increased deforestation.

The issue of climate change also continues to influence scientific studies and international cooperation efforts directed toward deforestation contemporarily. One example is the aforementioned Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) project. It is the largest program in international scientific cooperation ever to focus on this region, and it has become a site of political struggles to define the implications of climate change knowledge for deforestation policy, and vice versa.^{104–106} The projects main research questions are: (1) How does Amazonia currently function as a regional entity? (2) How will changes in land use and climate affect the biological, chemical, and physical functions of Amazonia, including the sustainability of development in the region and the influence of Amazonia on global climate? At its height, the LBA involved about 1700 participants, including 990 Brazilians, from 63 Brazilian and 143 non-Brazilian institutions.¹⁰⁷ Today it is administered by the National Institute of Amazonian Research (INPA), and is funded by Brazil's Ministry of Science and Technology.¹⁰⁸

This 20-year scientific effort helped shape current understandings of both the nature and extent of

deforestation, including its implications for the carbon balance in the region and globally. As stated in a recent comment piece¹⁰⁸: 'Tropical forests are big players in the global balance of climate and carbon, and the Amazon is the biggest of the lot' (p. 1). But the project was itself a site of struggles involving, among other things, concern over cooperation with NASA and different perspectives on the research agenda emerging from distinct disciplinary backgrounds, such as climatologists vs. 'human impact' experts, for example.¹⁰⁶ It's possible that the LBA's focus on carbon-cycle research can be related to its sources of funding (it began as a joint effort between Brazil, the United States and the European Union) and the research interests of its participants, many of which are centered on a natural science-dominated global environmental change research agenda with limited inclusion of social-scientific research.^{105,107}

Current science dealing with deforestation in Amazonia is trying to understand the synergistic articulations among drivers of forest destruction, including how road building (both official and unofficial) and paving is helping to bring changes in land use to areas once thought too remote for development^{71,76}; the role of selective logging¹⁰⁹; and the role played by fires and fragmentation of the forest.⁸⁵ All of these are possible tipping points that could lead to large-scale savannization.^{77,86} This interdisciplinary approach, which has gained support in the scientific community,¹¹⁰ attempts to grasp in different ways the complexity of phenomena that relate to Amazonian deforestation, to help explain regional and global climate changes now and in the future.¹¹¹

Scientific results related to the Amazon's carbon balance are disputed, however, as debates develop in science, the media and among decision makers.¹⁰⁴ Local political cultures constrain in important ways how science and policy interact,¹⁰⁴ and how local governments relate to science is central in understanding how deforestation politics will develop in the coming years.^{28,107} Some critique the way environmental policies in Brazil make it difficult for farmers to comply to the changing demands of legislation,¹¹² while others mention the contradictions present in such initiatives as Economic-Ecological Zoning (EEZ), which has been a very disputed attempt at ordering land use and development.¹¹³ Some point out that the real zoning has been done in practice by large scale development projects,¹¹⁴ which are implemented without actual dialog about impacts. Zoning seems to favor conservation where there is more political will, as in the states of Acre and Amapá,¹¹⁴ indicating that policy alone does not correlate with environmental protection.

Current policies are sometimes critiqued for focusing on stopping deforestation altogether, ignoring interactions between ecological, social and economic factors.¹¹⁵ Critics¹¹⁵ have argued for a more nuanced look at local realities, where drastic intraregional differences and lack of infrastructure persist, and where deforestation is related to different segments of the human population (peasants, ranchers and miners, for example). However, conservation policies have managed to reduce deforestation by implementing protected areas, strengthening environmental laws and improving their control,¹¹⁶ without compromising economic growth.¹¹⁷

The close (and problematic) interface between policies, politics and science related to deforestation became again very public during the debates in Brazil around the country's new Forest Code (Código Florestal), approved in 2012. Amid a heated controversy in the media, the Brazilian Academy of Sciences (Academia Brasileira de Ciências—ABC) and the Brazilian Society for the Advancement of Science (Sociedade Brasileira para o Progresso da Ciência—SBPC) published an open letter¹¹⁸ questioning the scientific basis of the bill and proposing a list of issues not contemplated by the text under discussion in Congress. Some of the issues in dispute were the protection of wetlands,¹¹⁹ amnesty for deforestation done before 2008,¹¹⁷ the need to reforest previously cleared areas¹²⁰ and the political standoff between President Dilma Rousseff and the conservative agribusiness interests strongly represented in Congress.^{117,120}

An important aspect of this debate was the place of scientists, which according to some were not being heard during the legislative process.¹¹⁸ The scientific community in Brazil was, however, intensely discussing the Forest Code, and trying to participate in redefining land use, conservation and how sustainable practices could be developed in that country without destroying natural resources. In a comprehensive study¹²¹ done to subsidize legislative discussions on the code, which included members of major scientific institutions in Brazil in dialog with politicians, scientists attempted to offer scientific grounding to their suggestions to the bill, which were largely ignored by Congress.

Overall, the Silva et al.¹²¹ study states that misuse of natural resources, a historical legacy of Brazil, could be countered by technological innovation.¹²¹ This discussion gains in political relevance as agribusiness becomes ever more central in Brazil's economy, putting pressure on forests already at risk.¹²¹ It thus frames the challenge as being one of how to maintain growing agricultural productivity while incorporating low carbon techniques and conservation as

principles not at odds with increasing outputs. Science and technology are offered as central means to achieve these goals,¹²¹ by enabling the recuperation of degraded lands and increasing productivity while protecting forests and other biomes.

CONCLUSION

As this review has shown, the science and politics related to deforestation have changed since the 1970s, and the issue of climate change has become increasingly central to this discussion. This correlates with changing environmental policies aimed at the Amazon, which have also incorporated climate change as part of their framing of deforestation. The idiom of emissions and global warming has found allies in parts of the scientific community, the media as well as civil society and some sectors of the government^{104,122} (exemplified by Sven Wunder et al. 'Pagamentos por Serviços Ambientais: perspectivas para a Amazônia Legal', a study commissioned by Brazil's Ministry for the Environment). This might also be happening at a global level, through mechanisms such as REDD¹²³ which incorporate carbon metrics into policy mechanisms. However, much more research would be needed to better establish how climate change knowledge has impacted environmental policies in the Amazon and elsewhere.

Currently, policies are being developed to address climate change in Brazil, and those are intrinsically tied to deforestation because of the national emissions profile, as discussed above. They have since 2009 internalized carbon constraints and are promoting the transition to a low carbon economy.¹¹⁷ Since most carbon emissions are due to land-use changes associated with deforestation, the issue of the Amazon's role in the global carbon balance becomes crucial not only for science, but for global environmental governance. Carbon storage, emissions, the circulation of moisture and other such concepts help reframe how diplomats negotiate in the global arena, and how local conflicts are fought, based on the level of legitimacy this knowledge has acquired.¹⁰⁴

However, the question of the Amazon in Brazil is politically charged, and the forest's relevance for the region and the world makes it an issue for continuous dispute, usually perceived through nationalistic lenses.^{13,124} Fears over a foreign invasion of the Amazon date back centuries,⁶ and there are important geopolitical implications to any attempts at discussing a role for international actors in the region.¹²⁴ Such specificities have continually shaped how

disputes around deforestation developed in this country, which holds two thirds of the Amazon forest. And as the example of the debate around the 2012 Forest Code in Brazil showed, the force of science to engender environmental protection through national laws and regulations has limits, is ambiguous and uncertain. Variables such as national histories, regional and even local politics and specific economic and development interests are central to the ongoing development of the politics/policies around deforestation and climate change in the Amazon.

NOTES

^a The term 'development' is in itself a very disputed concept, and is used here in more descriptive terms, relating to policies aimed at fomenting economic growth, the building of infrastructure (roads, dams, etc.) and increasing living standards. The article will not discuss current debates around sustainable development, green economy or other proposals that critically assess the meaning of development, as this would steer away from our central focus in this piece.

^b Groups inhabiting the margins of the many rivers in the Amazon region.

^c Small scale rubber tappers, who work collecting the sap from the seringueira tree (*Hevea spp.*).

^d Communities formed by runaway slaves, which remained isolated.

^e 'A yet more serious quarrel with the United States broke out earlier this year after the World Bank published figures on the extent of deforestation in the rain forest. The bank estimated that as much as 12% of the rainforest – 598,921 km², an area as large as Morocco – had been destroyed by fire and flooding since 1978. The figures incensed President José Sarney, who felt they were exaggerated. He promptly ordered INPE (National Institute of Space Research) to undertake its own study based on satellite data' (Ref 63, 202).

^f http://www.imazon.org.br/pagina-inicial-en?set_language=en&cl=en

^g <http://www.ipam.org.br/#>

^h <http://www.icv.org.br/>

ⁱ Law no. 12,187, 12/29/2009.

^j http://www.fundoamazonia.gov.br/FundoAmazonia/fam/site_pt

^k <http://www.mma.gov.br/florestas/control-e-prevencao-do-desmatamento/plano-de-acao-para-amazonia-ppcdam>

^l <http://www.mma.gov.br/port/sca/arpa/>

^m <http://www.cifor.org/>

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IPAM's Website. <http://www.ipam.org.br/#>

ICV's Website. <http://www.icv.org.br/>

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ARPA's Website. <http://www.mma.gov.br/port/sca/arpa/>