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PROFILE

# BR-319: Brazil's Manaus-Porto Velho Highway and the Potential Impact of Linking the Arc of Deforestation to Central Amazonia

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**Abstract** Brazil's BR-319 Highway linked Manaus, in the state of Amazonas, to Porto Velho, Rondônia, until it became impassable in 1988. Now it is proposed for reconstruction and paving, which would facilitate migration from the ''Arc of Deforestation'' in the southern part of the Amazon region to new frontiers farther north. The purpose of the highway, which is to facilitate transport to São Paulo of products from factories in the Manaus Free Trade Zone, would be better served by sending the containers by ship to the port of Santos. The lack of a land connection to Manaus currently represents a significant barrier to migration to central and northern Amazonia. Discourse regarding the highway systematically overestimates the highway's benefits and underestimates its impacts. A variety of changes would be needed prior to paving the highway if these potential impacts are to be attenuated. These include zoning, reserve creation, and increased governance in various forms, including deforestation licensing and control programs. More fundamental changes are also needed, especially the abandonment of the long-standing tradition in Brazil of granting squatters' rights to those who invade public land. Organizing Amazonian occupation in such a way that road construction and improvement cease to lead to explosive and uncontrolled deforestation should be a prerequisite for approval of the BR-319 and other road projects for which major impacts are expected. These projects could provide the impetus that is needed to achieve the transition away from appropriation of public land by both small squatters and by *grileiros* (large-scale illegal claimants). A delay in reconstructing the highway is advisable until appropriate changes can be effected.

**Keywords** Amazonia · BR-319 · Brazil · Deforestation · Highways · Manaus · Porto Velho · Roads

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## Introduction

Controling deforestation is the most pervasive problem in environmental management facing tropical forest areas such as Brazilian Amazonia. Highway construction and improvement decisions represent critical junctures in the series of events leading to forest loss. Highways have a keystone role in the deforestation process by stimulating influxes of population and investment that represent more proximal drivers of clearing. Highway-construction decisions are made by government agencies and are therefore more subject to influence based on environmental concerns than are the decisions of thousands of individual actors at the deforestation frontier (e.g., Fearnside 1987a). Highway decisions are also subject to requirements of environmental impact studies and licensing, providing opportunities for modifying the decisions or for demanding complementary measures. Understanding the decision process and finding ways in which it might be improved therefore has an important role in environmental management for these regions. A decision to build or improve a highway is the result of a wide range of considerations that must be examined in order to understand the decision-making process as it is and

to recommend ways in which this process might be improved. Our intent in this paper is both to extract these lessons and to clarify options available for the current decision on opening a migration route to central Amazonia.

## Amazon Highways and the History of BR-319

In 1970, Brazil's military dictatorship launched the Transamazon Highway, bisecting the Amazon region from east to west. At the same time, a vast network of additional highways was announced. The planned road network greatly exceeded the government's financial capacities, even in this period of Brazil's so-called ''economic miracle'' (e.g., Davis 1977). The plethora of planned roads also greatly exceeded what would be justified by economic benefits of improved transportation because the road-building program was partly motivated by questions of territorial control rather than economics. In 1971, a ''decree-law'' (No. 1164) gave the federal government control of all land within 100 km of any planned highway, even if the ''highway'' was nothing but a line drawn on a map. Announcement of the road network resulted in a vast area, totaling 2.2 million km$^2$ (almost half of the Legal Amazon region) being transferred from state to federal control (Brazil, PIN 1972). This decree-law was revoked in 1987 (by Decree-Law No. 2375), and any land within 100 km of a highway that had not yet been allocated to a specific purpose became *terra devoluta* (unclaimed land) under state control. This affects a substantial part of the land along BR-319, unlike other highways such as the Transamazon Highway and BR-163, which had been claimed by federal agencies. In January 2006, the federal government proclaimed a 15 million-ha area encompassing almost all of the land between the Madeira and Purus Rivers as an ''Area of Provisional Administrative Limitation'' and began forming a committee to recommend special measures to prepare the area for the highway project.

The BR-319 Highway, running 877 km north–south from Manaus to Porto Velho (Fig. 1), was originally built in 1972 (680 km) and 1973 (197 km). Government policy at the time required that all highways first be constructed as unpaved roads, only to be paved after a period of years had elapsed and if justified by the road's traffic. In the case of BR-319, however, a special exception was made, and the highway was paved immediately at the time of construction. Haste was


**Fig. 1** Brazil with locations mentioned in the text

such that much of the road was built in the rainy season with the extraordinary practice of laying down plastic sheets on top of the fresh asphalt.

The high priority given to initial paving of the highway is best explained as part of an informal package of public works and federal programs that was given to the state of Amazonas as a sort of compensation for heavier federal investments in the state of Pará (e.g., Mahar 1976, p. 360). Headquarters of the Superintendency for Development of Amazonia was established in Belém (capital of Pará), and the great majority of ranching and other projects financed by the agency were in Pará. Pará also got most of the Transamazon Highway and all of its settlements, as well as construction of the BR-163 highway and paving of the Belém-Brasília (BR-010) Highway, followed shortly after by the Tucuruí Dam. Amazonas, a traditional rival of Pará, was given the Manaus Free Trade Zone (SUFRAMA), the Balbina Dam, and the BR-174 and BR-319 Highways. Balance between states is important in explaining why large federal investments with little economic justification have sometimes been made in Amazonas. The Balbina Dam is the best-known example (Fearnside 1989a); the same considerations applied to BR-319.

In the 1970s and 1980s, BR-319 had little traffic, because industrial production from Manaus was more cheaply sent to markets in south-central Brazil by ship and even by air. Rondônia was still the destination of most migrants who followed the BR-364 (Cuiabá-Porto Velho) Highway from Paraná and other major source areas (Fearnside 1987b). By the time Rondônia was essentially full and overflowing with migrants, BR-319 had degraded to the point that road conditions inhibited migration further north. However, by the time bus service from Porto Velho to Manaus was suspended in 1988, enough migrants had found their way to Manaus and especially to Roraima to significantly affect development there. Poor road conditions on BR-319 convinced those leaving Rondônia to go to Acre or to the southern part of the state of Amazonas rather than to Manaus or to Roraima. The alternative to road transport was a 4-day boat trip from Porto Velho to Manaus, which represented a significant barrier to most of Rondônia's migrants, who have come from non-Amazonian parts of Brazil and are unaccustomed to boat travel. The thin layer of asphalt on BR-319 soon became a nearly continuous series of potholes, which are both more expensive to fill and more damaging to vehicles than would be the case on an unpaved road. Much of the route had to be driven on temporary tracks beside the road rather than on the roadbed itself. The road from Porto Velho to Humaitá has remained passable since the highway was built, and the first 200 km proceeding north from Humaitá were settled by colonists on 100-ha lots distributed by the National Institute for Colonization and Agrarian Reform (INCRA). Most of these lots have now changed hands one or more times and are consolidated into small ranches (*fazendolas*) of 500 ha or more.

The southern end of the highway has remained at least marginally passable for the first 100 km north of Humaitá, and to a lesser extent for the next 100 km. In 2001, the first 58 km to the north of Humaitá was repaved, as was the 100 km at the northern end of the highway from Careiro Castanho to Manaus. A 340-km stretch in the middle of the route remains impassable, although occasional convoys of vehicles have made the journey at the height of the dry season in some years (bridges have been maintained to allow access to microwave towers along the route). Reluctance to spend limited government resources on reconstructing BR-319 is undoubtedly a combined result of existence of a waterway (*hidrovia*) on the Madeira River parallel to the highway and the very high cost of maintaining a highway in an area where rainfall averages up to 2200 mm annually.

## Plans for Reconstruction

Reconstruction and repaving of BR-319 has been planned and postponed repeatedly. The project was initially included in the 1996–1999 ''Brasil em Ação'' (Brazil in Action) plan, but despite objections from the state of Amazonas, was withdrawn by the program's coordinator, José Paulo Silveira, because of the low economic justification as compared to the hundreds of other projects in the 4-year development plan (J. P. Silveira, public statement 1999). Paving the highway was subsequently included in the 2000–2003 *Avança Brasil* (Forward Brazil) program (Brazil, Programa Avança Brasil 1999; Consórcio Brasiliana 1998; Fearnside 2002), but only the two stretches mentioned above were actually paved (totaling 158 km). In the 2004–2007 *Plano Plurianual* (Pluriannual Plan), or PPA, launched under President Luiz Inácio Lula da Silva (Brazil, MPOG 2004) the BR-319 project appeared listed as expected for ''after 2007,'' meaning that it would not be built during the term of the plan. However, President Lula's Minister of Transportation, Alfredo Nascimento, is the former mayor of Manaus and has made the project a high priority (Banega and Simonetti 2005). Nascimento's political party (Partido Liberal: PL) has made extensive use of his promises to build the highway in television and other advertisements in preparation for the October 2006 election.

The schedule announced by the Minister of Transportation approximately 3 months before the intended date for beginning work implied that he considered an environmental impact study (EIA) and report on impact on the environment (RIMA) to be unnecessary. Instead of the EIA/RIMA, which must conform to federal norms and be completed and approved before beginning construction, the state government contracted the Federal University of Amazonas to draft a Report of Environmental Accompaniment to be done simultaneously with the construction project. The Minister of Transportation and the Amazonas state governor inaugurated the beginning of construction on July 9, 2005, but a judicial order halted the project on August 4. The Minister of the Environment announced on August 11, 2005 that the BR-319 reconstruction project would have to go through the environmental licensing process. On September 1, the Regional Federal Court issued an order lifting the judicial embargo until the main case is decided, and the Minister of Transportation announced immediate resumption of the reconstruction project.

Paving the BR-319 highway has great public appeal in Manaus. In March 2005, all 24 state deputies (representatives in the legislative assembly of Amazonas) signed a ''manifesto of support'' urging the federal government to pave the highway immediately. In Manaus, the highway is generally viewed as a means of exporting industrial products more cheaply to São Paulo and other major markets in south-central Brazil, and as a cheaper route for the city's inhabitants to travel to these areas, for example, for family visits. The fact that the road will facilitate travel in both directions, leading to greatly increased migration to Manaus, is scarcely mentioned (personal observation).

## Potential Impacts

### Impacts Along the Highway Route

Paving BR-319 will lead to transformation of the area along the highway route. Representatives of the industrial and civil construction sectors in Manaus argue that, because the highway has existed for a long time, reconstructing and paving it would have virtually no environmental effect because ''what was to be degraded has already been degraded'' (Almeida 2005). Unfortunately, past experience of road building and improvement in Amazonia has resulted in a pattern of deforestation spreading out from access routes once they are established, and an acceleration when they are improved. The rate of spread depends on various factors, but one that stands out as a highly significant predictor is the distinction between paved and unpaved roads (Laurance and others 2001, 2002; Nepstad and others 2000, 2001; Soares-Filho and others 2005, 2006).

The fact that little deforestation has occurred since the BR-319 Highway was initially opened is sometimes suggested as indicating that this region would suffer little impact were the road to be reconstructed and repaved. Lack of clearing along the route is attributed by some to excessive rainfall making the climate inappropriate for ranching and agriculture (Schneider and others 2000) and to economic disadvantages of the long distance to markets. However, physical differences are not so great between the southern half of the BR-319 route and areas that have become major deforestation hotspots in Amazonas since 2002 between Humaitá and Lábrea and between Humaitá and Apuí. Malaria is endemic and clearly debilitating along the highway route; however, malaria cannot explain the modest advance of deforestation in the years following original construction since the disease also affects other areas with high deforestation rates.

In the northernmost portion of the route, agriculture is unpromising because of less fertile soils (Brazil, Projeto RADAMBRASIL 1973–1982, vols. 17 and 18). The northern portion is occupied by hydromorphic soils (Histosols), which are less desirable for agriculture and ranching than the red–yellow podzolic soils (Ultisols) that occupy most of the first 300 km north of Humaitá (Brazil, Projeto RADAMBRASIL 1973–1982, vols. 17 and 18). Despite agricultural limitations, the northern portion of the highway has been the focus of settlement projects such as the Panelão and Igarapé Açu projects in Careiro Castanho county. Although poor soil offers some discouragement of deforestation, the notion that this somehow confers an immunity to clearing has been shown to be in error by frequent examples (e.g., Fearnside 1986).

Some indications of potential increase in deforestation along the highway route are evident. There have been a number of land purchases in anticipation of the paving, with capital-intensive agriculture (rice, to be followed by soybeans) being used on one property 120 km north of Humaitá and several areas 200 km north of Humaitá reportedly purchased by large soybean investors from Mato Grosso. However, in 2005 agricultural profitability was at an economic low point, with substantial drops in the prices of rice, soybeans, and beef causing losses for agriculture and ranching throughout Amazonia. Contributing factors included the lowest exchange rate of the Brazilian Real against the U.S. dollar in 3 years (R$2.4/US$) having fallen by 24% between June 2004 and June 2005, combined with

the normal economic equilibria between supply and demand for these commodities. The globalized nature of markets for these commodities resulted in low prices for all three commodities in 2005, even though Brazilian yields of rice and soybeans were both below normal because of rainfall irregularities, especially rain in the harvest season.

Another development indicating a potential increase in deforestation along the highway route if the road is repaved is arrival of landless migrants. Landless migrants have established a camp at Igarapé Realidade (100 km north of Humaitá: Fig. 2). Migrants in the camp at Igarapé Realidade are organized as a community (although they do not identify themselves as belonging to any national landless movement, such as the Movement of Landless Rural Workers). Two busloads of migrants were obliged to return to Rondônia after a confrontation with police, but approximately 30 families remained in the camp and surrounding area. Long-term residents in the area claim that they have started clearings in various parts of the *fundiária* area (public lands that lie behind the 2-km-deep strip of lots originally distributed by INCRA along the roadside). This area of public land already has various claimants, including long-term residents of the area engaged in gathering Brazil nuts (*Bertholetia excelsa*) and several larger claims by individual and corporate owners of blocks of lots along the highway. Residents along the highway believe that ownership of a roadside lot gives the owner the right to a virtually unlimited area of the public land lying behind the colonized area. INCRA states that colonists have no such right (David Benedito Gonçalves, personal communication 2005). However, as the Thomas theorem in sociology holds, ''If men define situations as real, they are real in their consequences'' (Thomas and Thomas 1928, pp. 571–572).

In addition to the migrants at Igarapé Realidade, a stream of freelance land seekers has appeared to stake out claims. Some of these are dropped off by boat on the banks of the Madeira River and then wander through the forest in search of unclaimed land. These individual agents from the already filled areas in Rondônia can be expected to travel to all points along the road once access is improved. Currently there is bus service up to 200 km north of Humaitá.

The claiming of large areas by *grileiros* leads to a pattern of violence in which hired gunmen remove any competing claimants. The head of the INCRA in Amazonas has denounced the prevalence of this pattern in the region (Litaiff 2005). The state governor's vision of the BR-319 becoming a ''corridor of family agriculture'' (*Amazonas em Tempo* 2005a) would appear to be an improbable scenario in the absence of first achieving success in implanting governance in the area.

Effect of BR-319 is not restricted to the area directly accessed by the highway, but also by a series of planned side roads that will connect BR-319 to municipal seats on the Madeira and Purus Rivers. These include Manicoré, Borba, Novo Aripuanã, and Tapauá. Plans for side roads are already stimulating resistance by local politicians to creation of reserves near proposed

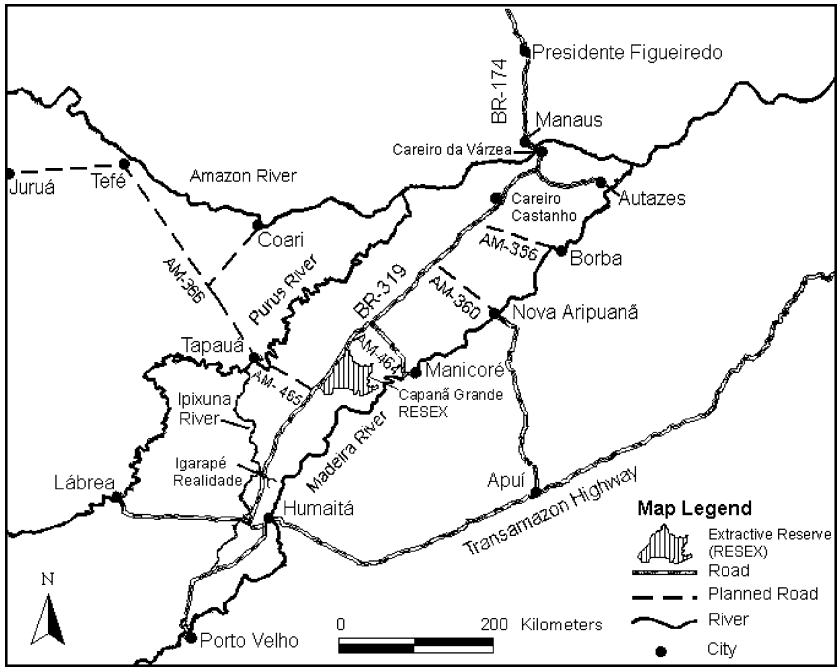


**Fig. 2** The BR-319 Highway

routes. A proposed indigenous reserve that borders the planned AM-465 road giving access to Tapauá is the focus of objections from city council members of Tapauá, who want land opened by this side road to be available for agriculture (*Amazonas em Tempo* 2005b).

Existence of protected areas of various types can significantly slow the advance of deforestation, reducing the probability that any given hectare will undergo a transformation from forest to another land use (Ferreira and others 2005). Sometimes the mere rumor that a reserve will be created can discourage invasion. At present, there are almost no reserves to restrict deforestation along BR-319, although talk of creating such reserves is a major preoccupation of large farmers and ranchers in Humaitá and along the occupied portion of the highway route. The Capanã Grande extractive reserve (RESEX) has been created by the federal government (Fig. 2). The state government has plans for creating the Rio Amapá sustainable development reserve (RDS). The area is of interest for reserve creation because the strip of land between the Madeira and Purus rivers along which BR-319 passes is an interfluve with particularly high biological diversity (Mario Cohn-Haft, personal communication 2005).

## Impacts in Central Amazonia

Manaus today is an island of peace that seems out of place in Amazonia. To the north of the city is the SUFRAMA Agriculture and Ranching District where large ranches were established in the early 1980s with generous fiscal incentives and government-subsidized financing packages. When the flow of government funds dwindled in the mid-1980s, most of the pasture was abandoned. Currently, more than 80% of the cleared area is occupied by woody secondary vegetation, yet no landless migrants invade the area; there are no battles between squatters and gunmen, no burned shacks, and no deaths. Abandoned ranches like these are virtually nonexistent in southern Pará, northern Mato Grosso, or Rondônia, because any such ranches would be invaded almost immediately.

The peaceful scenario in rural areas around Manaus could change overnight with opening of a paved link to the ''Arc of Deforestation,'' the crescent-shaped area along the eastern and southern edges of the Amazon forest where deforestation activity is concentrated. The relatively modest incursions of landless migrants on BR-319 currently, such as the encampment at Igarapé Realidade, are misleading as an indication of the scale of impact that occurs when new migration frontiers become available. The much stronger effect on frontier areas in southern Pará offers a better indication of this potential (Fearnside 2001). Estimates of the number of landless rural families in all of Brazil range from 5 to 10 million, greatly exceeding the capacity of the entire region even if entirely distributed in government settlement projects (e.g., Fearnside 1985).

Manaus could also expect to receive a substantially increased flow of urban migrants. Both rural-to-urban and urban-to-urban migration are powerful trends in Brazil's ongoing population flows (Brazil, IBGE 2005; Browder and Godfrey 1997). The industrial district in Manaus, which benefits from special tax exemptions as a part of SUFRAMA, employed 82,730 people in April 2005 (Brazil, SUFRAMA 2005a); this has been the principal magnet attracting population to the city (2005 population approximately 1.6 million).

Much of the migration to Manaus has so far come from riverside populations in the interior of Amazonia, but this flow could be dwarfed by new arrivals from the rest of Brazil were access to be made easier. Unemployment in Manaus is lower than in many Brazilian cities, although the reputation Manaus enjoys for high levels of employment is not entirely deserved. Manaus has 141 formal jobs per 1000 inhabitants; of the capital cities of Brazil's states, one third have more unemployment than Manaus whereas two thirds have less (Brazil, IBGE 2005). However, Manaus has the best ratio of employment to population of any capital city in Brazil's northern region.

Per-capita income provides another indicator of the attractiveness of Manaus as a migration destination. The state of Amazonas is far better off than surrounding states and has higher per-capita income than any other federal unit in Brazil with the exception of the Federal District (Brasília), Rio de Janeiro, São Paulo, Rio Grande do Sul, and Santa Catarina. Even Paraná, which is well known as a wealthy state, is slightly poorer than Amazonas. Per-capita income in Amazonas is more than double that of Pará and quadruple that of Maranhão (Fig. 3). Especially important for BR-319 is the fact that Amazonas has nearly twice the per-capita income of Rondônia. The city of Manaus is responsible for the state's high ranking. As a city, Manaus ranked third among the capitals of all 27 Brazilian federal units in terms of gross domestic product per capita in 2005, behind only Vitória (Espírito Santo) and Brasília (Distrito Federal) (Soares 2005).

Needless to say, arrival of large numbers of urban migrants in Manaus would stretch already precarious social services and increase urban problems such as unemployment, underemployment, urban invasions, and crime. One would expect migration from other parts of Brazil to be proportional to the disparity in

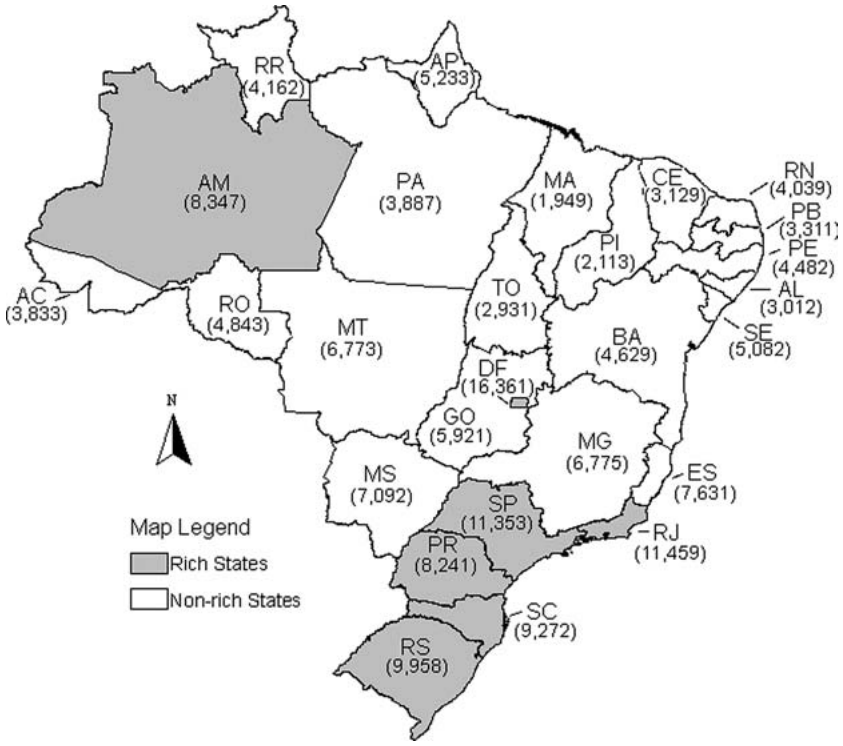


**Fig. 3** Per-capita income in Brazilian states in 2002 (data source: IPIB 2005). Values in Reais in 2002 (US$1 = R$2.28). ''Rich'' states have per-capita income more than R$8000. Abbreviations of federative units: AC = Acre, AL = Alagoas, AM = Amazonas, AP = Amapá, BA = Bahia, CE = Ceará, DF = Distrito Federal, ES = Espirito Santo, GO = Goiás, MA = Maranhão, MS = Mato Grosso do Sul, MT = Mato Grosso, PA = Pará, PE = Pernambuco, PI = Piauí, PR = Paraná, RJ = Rio de Janeiro, RN = Rio Grande do Norte, RO = Rondônia, RR = Roraima, RS = Rio Grande do Sul, SC = Santa Catarina, SE = Sergipe, SP = São Paulo, TO = Tocantins.

employment opportunities and living standards between source and destination locations, leading to a lowering of the attractive qualities of the destination location until an equilibrium is established (e.g., movements in Garcia and others 2004). The magnitude of disparity that can be maintained at equilibrium depends on the friction to migration represented by impediments such as lack of road access to Manaus. When these impediments are removed, the equilibrium would shift as heightened migration lowers the attractive features of the destination area. An example is provided by Sorriso, Mato Grosso: this small city, which is at the center of Mato Grosso's soybean boom, was the subject of frequent news reports because the economic boom had resulted in the area having the highest Index of Human Development in Brazil. A year later, the mayor of the Sorriso lamented that publicity of the Index resulted in the city becoming overrun with migrants. With five busloads of people arriving per day, the mayor is looking for ways to discourage the migration that has already increased the population of schoolchildren by 36% (Folha de São Paulo 2005).

### Impacts in Roraima

The potential for increased migration to Roraima is likely to be one of the principal impacts of paving BR-319. Aside from the long-standing population flow from Maranhão to Pará, Rondônia has become the principal source of migration to other Amazonian states, the main destinations being areas such as Apuí (in southern Amazonas), eastern Acre, and a significant movement to northwestern Mato Grosso (reversing the traditional flow from Mato Grosso to Rondônia) (e.g., Garcia and others 2004). Roraima is also a destination, although the difficulty of transportation restrains migration on this route at present. In the early 1980s, when BR-319 was passable, a substantial fraction of the migrants who arrived in Manaus on the highway continued directly to Roraima via BR-174, rather than settling in central Amazonia. This is partially explained by geochemistry—Roraima, located on the Boa Vista Formation, has younger, more fertile soils than the Manaus area. It is also partly explained by the active encouragement of the government of Roraima, which distributed land in settlement areas, provided services such as subsidized transport to markets, and even transported new migrants to the state as part of election strategies (Fearnside and Barbosa 1996).

## Highway Benefits

Benefits of paving BR-319 are much less than what is portrayed in political discourse surrounding the subject. The main justification presented is lowering of

transportation costs for freight to south-central Brazil, thereby increasing competitiveness of industrial products from Manaus on markets in São Paulo and other population centers. However, the industrial products of Manaus, such as television sets and motorcycles, are not perishable items for which reducing transportation time by a few days would make a significant difference. Shipment of such freight by ship to the port of Santos is much more efficient both in terms of energy use and in terms of labor costs than is shipment in thousands of trucks, irrespective of the highway route. The same arguments used as justification for BR-319 are simultaneously being used as part of the justification for paving the BR-163 Highway from Santarém to Cuiabá (e.g., Simonetti 2005, Brazil, SUFRAMA 2005b). Freight now taken from Manaus to Belém by barge and trucked to São Paulo via the Belém-Brasília (BR-010) Highway takes 11 days and would arrive in 5 days if trucked from Santarém (Brazil, BNDES 1998, p. 68). Counting the same freight in justifying BR-319 implies that this benefit would evaporate for BR-163. The current multimodal route through Porto Velho is cheaper than the route through Belém, but the Porto Velho route is only usable for part of the year because the Madeira River is not navigable in its low-water period. Water level in the Madeira River varies by 15 m over the course of the year, and depth at Porto Velho is only 2 m when water flow is at its annual minimum.

The trucking route from Manaus to São Paulo via the Belém-Brasília Highway would appear to lack logic when compared with movement of freight by cabotage, or coastal shipping, between Manaus and São Paulo's port at Santos. Brazil's National Bank for Economic and Social Development (BNDES), which is responsible for promoting transportation infrastructure development, has published transportation cost figures that directly contradict the political discourse promoting the highway project. BNDES estimates that use of the ships would reduce the door-to-door cost of freight by 50% as compared to current barge and highway options (Brazil, BNDES 1998, p. 102). However, ''transport of general cargo by cabotage is practically nonexistent'' (Brazil, BNDES 1998, p. 64). BNDES (1998, p. 100) states that ''the greatest impediment to movement of this freight by cabotage is in the inefficiency and unreliability of the ports. .... If fees and service quality were in accord with international standards, making regular operation of cabotage viable, freight between Manaus and the south-east region would fall to approximately R$3 thousand [US$2.6 thousand at the time] [per container], or half of the current cost.'' In addition to port costs, BNDES also emphasizes ''abusive'' prices of auxiliary services such as piloting fees on the Amazonas River that alone ''cost R$100 [US$86] [per container], on average, or 3% of the total freight cost between Manaus and São Paulo.''

The port of Manaus is the most inefficient in Brazil in terms of the number of hours needed to load or unload a ship: 36 hours, or twice the length of time required in Santos (Ono 2001, p. 43). In addition to being inefficient, the ports are also expensive. In a report by the National Confederation of Transportation, a ''necessary action'' identified to make cabotage viable is ''reduction of excess labor in the ports'' (CNT, nd [*C*. 2002], p. 148). Modernization has reduced the number of manual tasks, resulting in surplus workers. The National Confederation of Transportation outlines a negotiating strategy based on offers of early retirement for these workers. However, we would suggest that in the case of Manaus much of this could be unnecessary because the needed major expansion of the port should allow the present workforce to be retained.

Political discourse regarding the benefits of transporting the industrial output of Manaus to São Paulo by truck via either BR-163 or BR-319 may well bear little relation to what actually unfolds once the highways are paved. For example, paving of the BR-174 Highway in 1997 was justified by the claim that industrial products from Manaus would be trucked to Venezuela and exported from there by ship to the United States via Houston, Texas (Abdala 1996). This was calculated to save 15 days over exporting the products directly by ship from Manaus. Once the highway was paved, no trucks appeared to ply this new export route. The greater economic efficiency of exporting directly by ship is evident, the difference in cost outweighing the value of saving 2 weeks in transport. Nevertheless, discourse regarding a truck route to Venezuela served its purpose in gaining political support for the highway paving. Increased deforestation in Roraima is one of the ongoing costs of the BR-174 Highway.

The main benefit of BR-319 is likely to be political support for those able to take credit for its reconstruction. Construction would be with federal funds, not funds from taxpayers of the state of Amazonas. This difference in perspective can be a key factor in perception of whether major investments are worthwhile, the Balbina Dam near Manaus providing a clear example (Fearnside 1989a). Another influential group is construction firms and the array of potential suppliers of goods and services to the construction effort. As with any major public investment where financial costs

are borne by taxpayers spread throughout the country while commercial activity and employment generated in the construction phase are localized (e.g., in Manaus), a lobby of local support can be expected to develop even if the project in question has minimal economic justification. The Balbina Dam, for example, is known as a ''pharaonic'' project because, like the pyramids of ancient Egypt, it erected a massive structure at great cost with little or no practical return (Fearnside 1989a).

In addition to industrial freight, which is seen as leading to increased employment in Manaus, an important source of support for paving BR-319 lies in the imagination of middle-class residents of Manaus who visualize themselves making vacation trips to south-central Brazil, even though most such trips are likely never to take place (at least by road). Ending the ''isolation'' of Manaus proves to be a powerful slogan, but it is rarely remembered that this coin has two sides, the other being the arrival of a stream of migrants to Manaus.

## BR-319 and the Decision-Making Process

The decision-making process for paving BR-319 follows the pattern evident in other Amazonian infrastructure projects of substantially underestimating impacts and overestimating benefits of proposed public works. Most notable in this case is the effect of not counting major environmental and social impact of the road, namely, the impact of population flow to central Amazonia and to Roraima. Impacts of laying down the roadbed itself are minimal as compared to more far-reaching effects of population flow and increased deforestation activity (e.g., Fearnside 2005a). Deforestation provokes loss of environmental services such as biodiversity maintenance, water cycling, and carbon storage (e.g., Fearnside 2005b). These losses include increasing risk of passing thresholds that could lead to irreversible forest degradation.

The need for a rethinking of the plans for paving BR-319 at this time is suggested by high environmental and social costs and modest benefits when viewed in a more realistic light than that of the current political discourse. Impacts of the highway could be reduced if a decision on paving it were postponed by several years and if good use were made of the intervening time. One alternative would be a regular shipping service between Manaus and Santos. The port of Manaus is capable of handling ocean-going ships of all sizes, but shipping is primarily focused on foreign markets. Resistance to cabotage can be expected from firms that currently operate barges to Belém and Porto Velho, but this should be no more of an impediment than are the same firms with respect to the BR-319 reconstruction project. As of 1996 there were 15 firms transporting general cargo to Belém and eight firms to Porto Velho (Brazil, BNDES 1998, pp. 66 and 79).

The ecological–economic zoning of the state of Amazonas, already completed in preliminary form (Estado do Amazonas 2001), needs to be strengthened and implemented. In Roraima, a zoning has been completed but was left unimplemented because the state environmental agency failed to send it to the state's legislative assembly. What is needed as a prerequisite for a decision on paving the highway is not a plan or a committee, but real changes that are actually implemented before approval is granted. Assuming that mitigation measures will be implemented simultaneously with highway paving represents a formula for environmental disaster, as amply shown by the history of the BR-364 Highway (Fearnside 1989b).

Creation and implementation (including staffing) of reserves along the highway route is an important measure that needs to be in place not only before the highway is opened but before the effects of expectations of future paving further erode the possibilities of creating such areas. Reserves can form barriers parallel to the highway to contain the expansion of clearing from the edges of the road. In the case of extractive reserves, they also offer the possibility of maintaining some of the current economy based on Brazil nut gathering, an activity that is sacrificed wherever clearing advances and where local residents are replaced with recent arrivals from southern Brazil.

Lack of governance is a chronic problem on BR-319, as elsewhere in Amazonia. Both the federal environmental agency (Brazilian Institute for the Environment and Renewable Natural Resources) and the state agency (Institute for Environmental Protection of Amazonas) are very weak when compared to the challenges they face. Enforcement is minimal of environmental regulations such as those requiring a ''legal reserve'' of 80% of each property in areas of Amazonia where the original vegetation is forest, and the ''permanent protection areas'' along water courses and on steeply sloping land. A combination of remote sensing, field campaigns, and close cooperation between the enforcement agencies and the judicial system has shown itself to be effective in influencing land-clearing behavior in the case of Mato Grosso's licensing and control program from 1999 to 2001, that is, under a previous state government (Fearnside 2003; Fearnside

and Barbosa 2003). These methods have not yet been applied in Amazonas or Roraima.

A basic impediment to better governance is lack of land titling and a proper cadastre that would make it possible to identify who owns any given piece of land. This needs to be done without legalizing the claims of either *grileiros* (large illegal land claimers) or small squatters. Although a national cadastre is under preparation by INCRA, progress on this long-term project has not yet reached the BR-319 area. The Land Institute of Amazonas (ITERAM) has also not yet succeeded in mounting a georeferenced database of properties in the areas it controls.

Fundamental and far-reaching changes are needed, in addition to more palliative measures to contain deforestation through zoning, reserves, and enforcement of environmental regulations. The lack of employment alternatives needs to be addressed in both urban and rural contexts. In the rural context, factors acting to discourage hiring of labor include the heavy burden of ''social charges'' such as the government pension fund. Informal (unregulated) labor markets dominate in much of the Amazonian interior. Gross abuses, such as debt slavery, are a common result of the weak governance that undermines the enforcement of regulations of all types (e.g., Rocha 2005).

The types of land use chosen discourage creation of stable rural employment. Logging is a significant employer, but the unsustainability of this land use, even when done as part of approved management plans, leads to a continual movement of sawmills and logging frontiers. The deforestation process itself employs a significant workforce in Amazonia, but is necessarily a passing phenomenon in any given location (and, in the long run, in the region as a whole). After deforestation, the predominant land use is cattle pasture, which also employs few people. Where profitable, mechanized cultivation of rice and soybeans is increasingly present. This form of agriculture substitutes machinery and herbicides for hand labor. Among factors discouraging land uses that would employ more people in deforested areas is fear of hired laborers and/or sharecroppers gaining squatters' rights over land they cultivate. Strategies to avoid such land-tenure claims include periodic expulsion and replacement of workers and tenants.

Brazil urgently needs to make the transition away from relying on squatters' rights as an escape valve for inequalities and injustices of all types, as well as allowing and legitimizing large-scale appropriation of public land by *grileiros*. Eventually, this custom is bound to change as the limits of available forest area are approached. Both environmental and social benefits would be great if the transition could be achieved soon—well before it is forced on the country for lack of further forest to invade.

In places such as Europe and North America this transition has been made long ago: unemployed people who lack resources to start their own business are faced with the option of seeking some form of employment, either urban or rural. The idea would not even occur to them that they have an innate right to invade any ''unused'' land, such as public land in Amazonia, in order to start a new farm. At some time in the distant past, of course, the ancestors of virtually all people today claimed land by simply occupying it. In Brazil this form of transferring land from the public to the private domain has persisted to this day. Abandoning this tradition requires a change in the mindset of the population. Such changes in attitude can happen; the tradition of squatters' rights is not a fixed part of the landscape. An example is provided by settlement of the western part of the United States, where ''closing of the frontier'' in 1890 marked the end of this form of freelance settlement (Turner 1893). For such a change to occur in Brazil by means other than simply running out of land, some visible milestone is needed. If political will for such a change can be mustered, the decision process for highways like BR-319 could be the turning point for Brazil.

## Conclusions

Uncounted environmental costs of linking central Amazonia to the ''Arc of Deforestation'' need to be incorporated into the decision process *before* a decision is made to reconstruct and pave the BR-319 Highway. Although, over a time scale of decades, paving of this highway is logical to expect, environmental costs would be high if this is done without first preparing the areas to which potential impacts extend, including Roraima. Preparations include ecological–economic zoning, establishment of reserves, and increasing the level of governance to a point where impact from an increased flow of migrants could be contained. Organizing Amazonian occupation in such a way that road construction and improvement ceases to lead inexorably to explosive and uncontrolled deforestation should be a prerequisite for approval of the BR-319 and other road projects. A delay in reconstructing the highway would be advisable until appropriate changes can be effected. More fundamentally, Brazil needs to undergo a transition whereby the centuries-old tradition of granting land rights to migrants who invade areas of forest is ended. This means of

providing an escape valve for the country's many problems must be replaced with improved employment opportunities in both urban and rural areas before the transition is forced upon the country by decimation of the forest.

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## References

Abdala I. 1996. Governo retoma o projeto do asfalto da Manaus-Caracaraí. Amazonas em Tempo [Manaus] 29 January 1996, p. 8

Almeida P. 2005. Empresários defendem a BR-319. Amazonas em Tempo [Manaus] 29 March 2005, p. B-6

Amazonas em Tempo. 2005a. Rodovia BR-319 será o corredor de agricultura familiar. Amazonas em Tempo [Manaus]. 5 June 2005, p. A-5

Amazonas em Tempo. 2005b. Demarcação de terras em Tapauá gera polêmica. Amazonas em Tempo [Manaus]. 17 June 2005, p. B-7

Banega A., A. Simonetti. 2005. Alfredo garante: Enfim, a BR-319 será recuperada. Amazonas em Tempo [Manaus]. 6 March 2005, p. B-4

Brazil, BNDES. 1998. Transporte na região amazônica. Cadernos de infra-estrutura no. 7, BNDES, Rio de Janeiro, RJ, Brazil, 114 pp. http://www.finame.com.br/conhecimento/cadernos/aicad_07.pdf

Brazil, IBGE. 2005. IBGE. Instituto Brasileiro de Geografia e Estatística (IBGE), Rio de Janerio, RJ, Brazil. http://www.ibge.gov.br

Brazil, Ministério de Planejamento, Orçamento e Gestão (MPOG). 2004. PPA 2004–2007. Lista Geral de Projetos de Infra-estrutura. Setembro 2004. MPOG, Brasília, DF, Brazil. http://www.planobrasil.gov.br/arquivos/57_(LivroVermelho-nov2004).pdf

Brazil, PIN (Programa de Integração Nacional). 1972. Colonização da Amazônia. PIN, Brasília, DF, Brazil, 32 pp

Brazil, Programa Avança Brasil. 1999. PPA Plano Plurianual 2000–2003. Ministério de Planejamento, Brasília, DF, Brazil. http://www.abrasil.gov.br

Brazil, Projeto RADAMBRASIL. 1973–1982. Levantamento de recursos naturais. Ministério das Minas e Energia, Departamento de Produção Mineral (DNPM), Rio de Janeiro, RJ, Brazil, 27 vols

Brazil, SUFRAMA. 2005a. Indicadores de desempenho do pólo industrial de Manaus. Superintendência da Zona Franca de Manaus (SUFRAMA), Manaus, Amazonas, Brazil

Brazil, SUFRAMA. 2005b. Pólo industrial de Manaus. Superintendência da Zona Franca de Manaus (SUFRAMA), Manaus, Amazonas, Brazil. Powerpoint presentation

Browder J. O., B. J. Godfrey 1997. Rainforest cities: Urbanization, development and globalization of the Brazilian Amazon. Columbia University Press, New York, NY, 427 pp

CNT. nd [C. 2002]. Transporte de cargas no Brasil: Ameaças e oportunidades para o desenvolvimento do País. Diagnóstico e Plano de Ação. Confederação Nacional do Transporte (CNT) & Centro de Estudos em Logística (COPPEAD), Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil, 200 pp

Consórcio Brasiliana. 1998. Programa Brasil em ação: Eixos nacionais de integração e desenvolvimento. Banco Nacional de Desenvolvimento Econômico e Social (BNDES) PBA/CN-01/97. Relatório final do marco inicial, Consórcio Brasiliana, Brasília, DF, Brazil, 3 vols

Davis S. 1977. Victims of the miracle: Development and the Indians of Brazil. Cambridge University Press, Cambridge, U.K., 205 pp

Estado do Amazonas. 2001. Zoneamento ecológico-econômico no Estado do Amazonas. Junho de 2001. Diretrizes iniciais para um ordenamento ecológico-econômico do sudeste-sul do Estado do Amazonas. Instituto de Proteção Ambiental do Amazonas (IPAAM), Manaus, Amazonas, Brazil

Fearnside P. M. 1985. Agriculture in Amazonia. Pages 393–418 *in* G. T. Prance, T. E. Lovejoy (eds), Key environments: Amazonia. Pergamon Press, Oxford, U.K., 442 pp

Fearnside P. M. 1986. Settlement in Rondônia and the token role of science and technology in Brazil's Amazonian development planning. Interciencia 11:229–236

Fearnside P. M. 1987a. Causes of deforestation in the Brazilian Amazon. Pages 37–61 *in* R. F. Dickinson (ed), The geophysiology of Amazonia: Vegetation and climate interactions. John Wiley & Sons, New York, NY, 526 pp

Fearnside P. M. 1987b. Deforestation and international economic development projects in Brazilian Amazonia. Conserv Biol 1:214–221

Fearnside P. M. 1989a. Brazil's Balbina Dam: Environment versus the legacy of the pharaohs in Amazonia. Envir Manage 13:401–423

Fearnside P. M. 1989b. Ocupação humana de Rondônia: Impactos, limites e planejamento. Relatórios de pesquisa no. 5,: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brasília, DF, Brazil, 76 pp

Fearnside P. M. 2001. Land-tenure issues as factors in environmental destruction in Brazilian Amazonia: The case of southern Pará. World Dev 29:1361–1372

Fearnside P. M. 2002. Avança Brasil: Environmental and social consequences of Brazil's planned infrastructure in Amazonia. Envir Manage 30:748–763

Fearnside P. M. 2003 Deforestation control in Mato Grosso: A new model for slowing the loss of Brazil's Amazon forest. Ambio 32:343–345

Fearnside P. M. 2005a. Carga pesada: O custo ambiental de asfaltar um corredor de soja na Amazônia. Pages 397–423 in M. Torres (ed), Amazônia revelada: Os descaminhos ao longo da BR-163. Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brasília, DF, Brazil, 496 pp

Fearnside P. M. 2005b. Deforestation in Brazilian Amazonia: History, rates and consequences. Conserv Biol 19:680–688

Fearnside P. M., R. I. Barbosa. 1996. Political benefits as barriers to assessment of environmental costs in Brazil's Amazonian development planning: The example of the Jatapu Dam in Roraima. Envir Manage 20:615–630

Fearnside P. M., R. I. Barbosa. 2003. Avoided deforestation in Amazonia as a global warming mitigation measure: The case of Mato Grosso. World Resource Rev 15:352–361

Ferreira L. V., E. Venticinque, S. S. de Almeida. 2005. O Desmatamento na Amazônia e a importância das áreas protegidas. Estudos Avançados 19:1–10

Folha de São Paulo. 2005. Em Sorriso, estrada divide Daslu e miséria. Folha de São Paulo. 19 June 2005, p. B-4

Garcia R. A., B. S. Soares-Filho, D. O. Sawyer. 2004. Dimensões socio-econômicos e movimentos populacionais: uma regionalização da Amazônia brasileira. Associação Brasileira de Estudos Populacionais (ABEP) Anais 2004. ABEP, Campinas, SP, Brazil. http://www.abep.nepo.unicamp.br/site_eventos_abep/PDF/ABEP2004_663.pdf

IPIB. 2005. IPIB—Internet produto interno bruto. Rio de Janerio, RJ, Brazil http://www.ipib.com.br

Laurance W. F., A. K. M. Albernaz, G. Schroth, P. M. Fearnside, S. Bergen, E. M. Ventincinque, C. da Costa. 2002. Predictors of deforestation in the Brazilian Amazon. J Biogeog 29:737–748

Laurance W. F., M. A. Cochrane, S. Bergen, P. M. Fearnside, P. Delamônica, C. Barber, S. D'Angelo, T. Fernandes. 2001. The future of the Brazilian Amazon. Science 291:438–439

Litaiff P. 2005. Grilagem: Balas protegem as terras. Terras ocupadas por grileiros nos municípios do Sul do Amazonas são protegidas à bala por pistoleiros. Amazonas em Tempo [Manaus]. 4 June 2005, p. B-7

Mahar D. J. 1976. Fiscal incentives for regional development: A case study of the western Amazon Basin. J Interam Studies World Affairs 18:357–378

Nepstad D. C., J. P. Capobianco, A. C. Barros, G. Carvalho, P. Moutinho, U. Lopes, P. Lefebvre. 2000. Avança Brasil: Os custos ambientais para Amazônia. Instituto de Pesquisa Ambiental da Amazônia-IPAM, Belém, Pará, Brazil, 24 pp (available at: http://www.ipam.org.br/publicacoes/avancabrasil/)

Nepstad D. C., G. Carvalho, A. C. Barros, A. A. Alencar, J. P. Capobianco, J. Bishop, P. Moutinho, P. Lefebvre, U. L. Silva Jr, E. Prins. 2001. Road paving, fire regime feedbacks, and the future of Amazon forests. Forest Ecol Manage 154:395–407

Ono R. T. 2001. Estudo de viabilidade do transporte marítimo de conteiners por cabotagem na costa brasileira. Masters dissertation in engineering, Escola Politêcnica da Universidade de São Paulo, São Paulo, SP, Brazil, 136 pp

Rocha J. 2005. Trabalho escravo: Presente, passado e futuro. Pages 237–269 *in* M. Torres (ed) Amazônia revelada: Os descaminhos ao longo da BR-163. Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brasília, DF, Brazil, 496 pp

Schneider R. R., E. Arima, A. Veríssimo, P. Barreto, C. Souza Junior. 2000. Amazônia sustentável: Limitantes e oportunidades para o desenvolvimento rural. World Bank, Brasília, DF and Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), Belém, Pará, Brazil, 58 pp

Simonetti A. 2005. BR-163: Preservação em primeiro lugar. A secretária de Coordenação da Amazônia do Ministério do Meio Ambiente, Muriel Saragoussi, garante que a recuperação da rodovia BR-163 vai beneficiar a Zona Franca. Amazonas em Tempo [Manaus] 1 April 2005. p. A-3

Soares P. 2005. Manaus é 3° PIB nacional. Amazonas em Tempo [Manaus] 19 November 2005. p. A-7

Soares-Filho B. S., D. C. Nepstad, L. M. Curran, G. C. Cerqueira, R. A. Garcia, C. A. Ramos, P. Lefebvre, P. Schlesinger, E. Voll, D. McGrath. 2005. Cenários de desmatamento para Amazônia. Estudos Avançados 19:138–152

Soares-Filho B. S., D. C. Nepstad, L. M. Curran, G. C. Cerqueira, R. A. Garcia, C. A. Ramos, E. Voll, A. McDonald, P. Lefebvre, P. Schlesinger. 2006. Modelling conservation in the Amazon basin. Nature 440:520–523

Thomas W. I., D. S. Thomas 1928. The child in America: Behavior problems and programs. Alfred A. Knopf, New York, NY, 602 pp

Turner F. J. 1893. The significance of the frontier in American history, Proceedings of the American Historical Association for 1893. Pages 199–222. Reprinted in expanded form: The frontier in American history. Dover Publications, Mineola, NY, 384 pp (1996)