

# **The Frontier Forest as a Specific Type of Social-Ecological System: A Comparative Study of Brazil and the US**

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## **1. Introduction**

The problem of deforestation is often presented as if it were a modern problem confronting only current developing countries. But every developed country was once a developing country, and deforestation problems are nearly as old as the earliest human settlements, especially in so-called “frontier” areas representing the boundaries between settlements and (supposedly) unsettled lands. Tomb paintings show trees being cut to clear land for planting in Ancient Egypt, where deforestation became “a major problem” (Hughes 2014, p. 40). The area around ancient Athens (except for Mount Athos, which was protected from logging by religious dictate) was pretty much devoid of trees by the fifth century BCE (Ibid., p. 76). According to Hughes (1994, p. 73), “No environmental problem of the Greeks and Romans was as widespread and prominent as the removal of forests and ensuing erosion.”

Deforestation appears to be ubiquitous in the history of human settlement and development (CITE). If so, then we might expect deforestation to have common causes across human societies, i.e., to represent an identifiable type of social-ecological system that poses common problems for collective action. As such, the concept of the “frontier” becomes useful for distinguishing between states or stages of development. Some scholars have gone so far as to suggest a general theory of “forest transition,” according to which deforestation is a common feature of early development, which eventually slows and reverses, so long as appropriate institutions are created (see, e.g., Barbier, Burgess, and Grainger 2010). This paper contributes to that literature by comparing the social-ecological circumstances of twentieth-century deforestation in Brazil’s “forest frontiers” and deforestation in US “forest frontiers” from the colonial era into the second half of the nineteenth century. After comparing and contrasting the two cases, we posit as a hypothesis (to be subject to further testing) that “frontier” conditions represent a distinctive type of social-ecological system, which can be described using a combined IAD-SES analysis comprised of a set of fairly consistent variables that typically are not found in forests after frontiers have closed.

## **2. American Forest Frontiers in the Nineteenth Century**

Deforestation in America predated European colonial settlement, just as it did in many other places around the world (e.g., Africa, Canada, Australia). Aboriginal peoples used fire to facilitate hunting or to convert forested lands for agriculture (see, e.g., Keeley 2002; Cronon 1983, pp. 12-13, 48-49). The tall-grass prairies that many people mythologize as the “natural condition” of “prairie states,” including Indiana and Illinois, were in fact created by aboriginal Americans who regularly burned forests and shrublands (see, e.g., Abrams and Nowacki 2008, p. 1125). The

environmental historian William Cronon (1983, p. 50) quotes a colonial settler from southern New England (ironically, named Wood): “In those places where the Indians inhabit, there is scarce a bush or bramble or any cumbersome underwood to be seen....”

Later, native tribes were often victimized by unscrupulous frontier foresters, but they also were sometimes co-opted or even complicit in forest destruction, as when an Ojibwa chief in Minnesota accepted payments from timber barons for cutting trees within his tribe’s jurisdiction. As Cox (2010, p. 196) observes, neither the lumbermen nor the tribal chief “saw a need to approach federal authorities for permission to cut,” as required by federal laws (including Indian Non-Intercourse Acts of 1790, 1793, 1796, 1799, 1802, and 1834 all of which prohibited private property acquisitions from native Americans). Indeed, the unlawfulness of lumbering practices is among the consistent themes in the history of forestry in America.

Another theme in the history of frontier forestry in the US – and in US History more broadly – is the geographic progression from East to West. The American forest frontier began on the Eastern Seaboard, especially in northern New England. From there, as forests became “played out” like valuable mineral deposits, the forest frontier forest range moved steadily westward through Pennsylvania, Ohio, Michigan, Wisconsin and Minnesota (with a swing into the Southeast after the Civil War), eventually reaching the great coniferous forests of the Northwest Coast and northern California.

Early colonists had little interest in timber for commercial purposes; they mainly cut trees to clear land for agriculture. But it was not long before they found that commercial purposes and agriculture were compatible. As local populations increased, timber had value not only for domestic purposes, but for commercial enterprises including brickmaking, staves, manufacturing of pig-iron, potash (extremely useful in agriculture), and shipbuilding, which of course became a major industry in the Northeast. Outside of growing season, many farmers supplemented their generally meager incomes by timber harvesting. Indeed, “[t]he growing commercial importance of timber and other forest products encouraged farmers, especially those in areas marginal for agricultural, to spend more time in the woods and less in their fields” (Cox 2010, p. 9). Some enterprising farmers even operated small sawmills (Cox 2010, p. 5). It was not long before deforestation in Massachusetts, New Hampshire, and Maine grew severe enough that colonial authorities established the first formal rules on the continent designed to conserve woodlands (Kawashima 1992). As with most resource conservation measures before the twentieth century, they were largely ineffective.

Virtually all timber harvesting outside of privately-owned plots of land (where many trees were nevertheless felled by trespassers) was strictly illegal, violating either the rights of aboriginal tribes or “his Majesty’s Woods.” Permission to cut trees was hardly ever asked, but there was little the Crown or its American governors could do to stop it, if they had wanted to do so. In fact, they increasingly benefitted both indirectly from the economic development forestry generated and directly from taxes on sales and exports of trees and products made from them. The only partial exception was relatively strict enforcement of rules against felling large, straight pines marked for export to the British Navy (Cox 2010).

[Insert Figure \_\_ on US States and Territories, ca 1800 about here.]

## **Bangor, Maine: America's First Major "Forest Frontier," circa 1820**

According to Cox (2010, p. 23), the first real "forest frontier" in the US— a place that was settled primarily for forestry — was centered in Bangor, Maine around 1820 (the year that Maine separated from Massachusetts). By that time, coastal areas of Maine already had been cleared, and foresters were forced to travel inland, along rivers that were necessary to transport the timber, up to 50 miles in search of high-value trees (Cox 2010, p. 38). Bangor was founded in 1769, and many, if not most, of its early settlers were squatters. Between 1786 and 1792, the number of sawmills in Maine increased by 50 percent (to 366) (Cox 2010, p. 39). Much of the demand for the timber products they produced were for Maine's growing ship-building industry. And trespass to cut trees became an accepted practice. As one observer put it, "it has long since ceas'd to be a crime to plunder the forests of this country" (Quoted in Cox 2010, p. 40). At its height, in the early 1840s, the Port of Bangor reportedly was shipping more lumber than any other port in the world (Cox 2010, p. 50). And water was no longer the only method of moving sawed timber long distances. In 1836, a rail line opened connecting Bangor directly to Milford, Massachusetts, only a short distance away from Boston Harbor, which gave easy access to export and domestic markets. This was a harbinger of things to come. By 1860, however, Bangor's "glory days" as a forest frontier had passed, though it continued to supply a great deal of wood to market for many more decades (Cox 2010, p. 69). Even before it hit its peak production, the lumber industry was already moving on to new frontiers.

## **The Forest Frontier Shifts to the Mid-Atlantic States, ca. late-1840s**

Before the 1820s, logging in New York was mostly about land-clearance for agriculture. By 1840, both New York and Pennsylvania had more sawmills than Maine, and New York's production of timber was more than twice that of Maine. And that happened *before* the mid-Atlantic became a "lumberman's frontier" according to Cox (2010, p. 73). Already in 1775, an observer noted that, however plentiful timber might be elsewhere in the State of Pennsylvania, it was so scarce around Philadelphia that it was as expensive as in Britain. Another wrote that the area had "a bare appearance, being totally stripped of trees" (Cox 2010, p. 75).

What made the mid-Atlantic states the new forest frontier by the 1840s was the opening of the Erie Canal (in 1825) and, especially, its feeder canals that provided relatively easy transport to markets for timber harvested in northern New York and north-central Pennsylvania. The Erie Canal also led to the first shipments of timber from as far West as Michigan, which arrived as early as 1840. That signified just how much demand for lumber was outstripping supply among all the growing cities of the East and foreshadowed by 20 years a subsequent shift in the forest frontier.

Before that, by the late 1840s, Glen Falls, New York (north of Albany) and Williamsport, Pennsylvania, located on the West Branch of the Susquehanna River, emerged as twin capitols of the US forest frontier (Cox 2010, p. 94). Glen Falls was only four miles downstream from the half-mile long "Big Boom," a device designed to collect hundreds of thousands of trees floated downstream from logging operations, where they could be sorted and released to smaller booms downstream where the sawmills would retrieve them (Ibid, p. 97). At its peak in 1872, the Big Boom corralled more than one million felled trees, and between 1852 and 1860 New York was the country's largest producer of timber (Ibid, p. 98). Williamsport reached its apex of lumber production around the same time. By 1866, the city had 30 sawmills with combined capacity of

nearly a million board feet per twelve-hour day (Ibid., p. 101). By this time, transportation of felled timber by rail was no longer a novelty. Trains could move far more timber, far more quickly, over far greater distances than any other method of transportation.

By the time a forest region is at peak production that means, almost by definition, that the forest “frontier” has shifted once again. “In most forest regions, logging commenced when the lumbermen’s frontier reached it, rose rapidly to a peak, and then quickly declined” (Cox 2010, p. 120). By 1874-5, Pennsylvania Governor John E. Hartranft issued a call for conservation legislation, warning that within 30 years all of Pennsylvania’s forests would be gone (Ibid, p. 121). This was another theme that emerged as the forest frontier moved across the United States: from a perception of forests without end, when the first lumbermen arrived, the public (and therefore politicians) quickly grew weary not only of the industry and its power, but the conditions it was creating on the ground. By the time of peak production, warning bells rang that the formerly endless forests were, in fact, in very short supply.

### **The Forest Frontier Moves to the “Northwest Territories,” ca. 1860**

The southern parts of the Northwest Territory were quickly populated and attained statehood: Ohio in 1803, Indiana in 1816, and Illinois in 1818. Given logging’s traditional ties to agricultural settlement, it is somewhat surprising that the settlement of Indiana was delayed because it already had so few forests to clear. Cox (2010, p. 126) notes that settlers were reluctant to move to its prairies *because* of the lack of sources of wood for building and fencing. But, just like in Ohio and Michigan, as the settlers moved in, trees came down.

[Insert Figure \_\_ on “The Northwoods” about here.]

The northern tier of the Northwest Territories – Michigan, Wisconsin, and Minnesota – were opened for settlement later than the southern tier of Ohio, Indiana, and Illinois, and, with their harsher winters, they were settled more slowly, becoming states in 1837, 1848, and 1858, respectively. Up until the time of statehood, there was little pressure on the Northwoods forests because timber was still relatively plentiful closer to seaboard markets in Central and Western Pennsylvania as well as in northern New England. In the 1830s, hardly anyone thought of Michigan as forest frontier, even though 90 percent of the state was covered by forests.

In 1831, Alexis de Tocqueville and Gustave de Beaumont traveled to Saginaw in the “Siberia of Michigan,” the “last inhabited place till the Pacific,” as part of their research that resulted in Tocqueville’s immortal, *Democracy in America* (1835-40) (Ibid. p. 127). Tocqueville gave no hint of an existing forest industry but predicted that “In a few years these impenetrable forests will have fallen, [and] the noise of civilization and industry will break the silence of the Saginaw” (quoted in Cox 2010, p. 127). For his part Beaumont wrote that the local settlers had to spend half their time “fighting the natural enemy: the forest,” going at it “without respite.... The absence of trees is the mark of civilization, as their presence indicates barbarity” (Ibid.) This was decades before Michigan became a forest frontier.

Like the two Frenchmen, the earliest forest frontiersmen arrived in Michigan in the early 1830s, but forestry as an industry did not flourish for decades. In contrast to the Eastern states, in the case

of the Northern Tier of the Midwest (Michigan, Wisconsin, and Minnesota), the foresters arrived well before the settlers. In other words, suppliers preceded demanders. It wasn't until the 1850s that lumbering really took off in Michigan, thanks in part to technological innovations – larger, steam-powered mills – as well as reductions in transportation costs, which meant that, for the first time, almost all the timber could be sold far from its place of extraction (Ibid., p. 131). Once again, trespass to trees became routine. A grant of 40 acres of trees became a more elastic 40 “round” acres (Ibid., p. 132). After an economic recession stifled growing demand just before the start of the Civil War, the war itself exponentially increased demand for timber, which turned the entire Upper Midwest into a forest frontier.

In addition to supplying war needs, the Northwoods supplied growing populations in the prairie states between the Mississippi River and the Rocky Mountains. Instead of sending timber to Eastern markets, Midwestern foresters helped turn Chicago into “Nature’s Metropolis” (see Cronon 1992). In the 1850s, Chicago became the rail hub for shipments to the West, where wood was in especially short supply. As Anderson and Hill (1975) have noted, many parts of the great prairie remain empty of homesteads until barbed wire was invented in 1873 because wood for fences was scarce and expensive. Nevertheless, Chicago’s rail network allowed timber companies to ship more timber, including timber of lower value, more profitably. And in contrast to other prevalent modes of transportation, trains had the advantage of operating year-round (Cox 2010, pp. 134, 138). By 1857, just 25 years after its incorporation as a city, more than 150 lumber firms, worth \$60 million and employing 10,000 workers, were in Chicago (Ibid., p. 134).

By 1885, the forests of Michigan’s lower peninsula had been “all but cleared,” and the pine forests of the North Peninsula were yielding logs less than half the size of trees cut just a decade earlier. Production in the Saginaw Valley peaked in 1882 (Ibid., p. 146). By this time, clearcutting had come into regular practice, and loggers went back to re-cut areas that had been selectively harvested earlier. As Michigan forests were denuded, the center of operations moved to Wisconsin and Minnesota.

[Insert Fig. \_\_. Photo of Michigan clear cut about here.]

Major development of Wisconsin’s lumber industry did not take place until 1860, just before the Civil War (Hurst 1964, p. 13). That state’s first population explosion – from a few hundred in the early 1820s to ten thousand by 1829 (which caused Wisconsin to be broken off from the Michigan territory) – had nothing to do with forests and everything to do with valuable lead deposits in the southwestern part of the territory. Many miners lived in caves, like Badgers, which earned Wisconsin the moniker Badger State. At one point, they produced half of the nation’s lead (Cox 2010, p. 150).

The miners were soon followed by homesteaders, who came by newly opened steamboat service, facilitated by the opening of the Erie Canal, from Buffalo to Green Bay and Milwaukee. These were mostly farmers, who populated the south-central and south-eastern regions of the state. And the lumbermen followed the settlers, in the first place to supply growing local demand for wood, as well as the “almost insatiable” demand further south in Chicago (Cox 2010, p. 151). Nearly half of all wood shipped to Chicago at that time was used to meet the city’s own growth. Like Michigan, Wisconsin was well-suited to meet the demand with 60 percent of the state in forests (Ibid., p.

151). Unlike in Michigan, forest clearing in Wisconsin was not fragmented but became controlled by just a few big men, the biggest of which was Frederick Weyerhaeuser (Ibid., p. 154). By 1860, Wisconsin was producing 335 million board feet per year worth \$2.5 million, and most of that wood was sold in Chicago. The Wisconsin forest frontier started out along the western shores of Lake Michigan, which provided the easiest mode of transportation to Chicago. As the foresters worked their way west through the state, it became easier for them to supply the Great Prairie via the Mississippi and its numerous tributaries – the Wisconsin River alone cuts the entire state in half, running from Lake Superior in the North Central part of the state all the way to the Mississippi in its Southeast corner. But the spread of rail lines from Chicago also allowed timber harvested in the Eastern part of Wisconsin to meet demand of homesteaders in the Great Prairie as well.

As timber production reached its peak in Wisconsin, the frontier moved to Minnesota, which was also heavily timbered, though mainly with trees of lower value for construction. But with ever increasing demand by homesteaders in the Great Prairie and falling costs of transportation, even marginal timber stands could be profitably cleared. The forest frontiers continued to move West, all the way to the Pacific. In the South, too, forestry had become the second largest industry by 1860 (Cox 2010, p. 222). But already, by the last two decades of the nineteenth century, the closing of America's forest frontiers was in sight. So, too, was the devastation wrought by the cut-and-move approach to forestry on the frontiers.

### **The Closing of America's Forest Frontiers and the Evolution of Conservation- and Preservation-Based Forest Management**

As the foresters followed (or sometimes led) the settlers, complaints followed the foresters – for their unruly behavior (they were not Jefferson's yeoman farmers), their trespasses and other violations of state and federal laws, and their cut-and-move approach to harvesting, which left in its wake devastated, nearly worthless lands. The background, character and approach to the land of the American frontier forester was surprisingly consistent:

'early Lake States lumbermen largely came from rural backgrounds, for forests were ubiquitous and familiar to nearly every farm boy, the costs of entry low, and the technology simple and remarkably similar to that used on the farm. A part of their ideological baggage was a belief that land should be brought into production. If carving a farm from a forest was part of that process, and squatting a means to that end, so too was going into the forest to fell timber and, legal title aside, selling or milling the resulting logs....

'There was a libertarian strain to all this. Not only did the land by right belong to those who lived and worked thereon, but also outsiders who sought to regulate what could be done on it were opposed or ignored.... In the end, community sentiment, not laws propagated and enforced by outsiders, determined how jury members voted. (Cox 2010, pp. 197-198).

Those "outsiders" – the would-be regulators – were in any case conflicted and inconsistent in policies and enforcement. As we have seen, trespass was a ubiquitous practice along all frontier forests. Lumbermen trespassed onto privately owned land and tribal lands, but mostly they trespassed onto federally owned public lands (mostly western colonial territories voluntarily ceded by the states after the Revolutionary War). According to some sources (e.g., Opie 1987, pp. 45-6),

“Most trespassers honestly believed that the public lands were a national commons available for free settlement and profitable development by the first taker.” Indeed, under the federal land disposition policy that lasted for most of the nineteenth century, the public domain was open to settlement under various federal homesteading and land-sale laws. Once a territory acquired statehood, ownership of remaining federally owned lands passed to the states, which in turn sought mainly to dispose of them to private landowners. This was all part of Thomas Jefferson’s scheme, reflecting most prominently in the Northwest Ordinances of 1784, 1785, and 1787, to create a democratic republic of yeoman farmers, who would become responsible citizens because landownership would give them real stakes in political decisions of their local communities and states. The same could not be said of rootless loggers, who moved from one cut, in one territory, to the next cut, perhaps in another territory, whether with or without authorization by federal or territorial officials. Land settlement that was supposed to occur according to a rational process, territory by territory, in accordance with land surveys based on Jefferson’s own “township” and “section” grid system. Many homesteads were established in accordance with the law, but the regular pattern was illegal settlement followed by ratification of titles under federal “preemption” statutes.

In 1831, Congress enacted a law that made it a crime to “cut, destroy, or remove live oak or other trees belonging to the United States, but the statute was unenforceable; there were far too many acres and settlers for the handful of federal employees to monitor” (Wilkinson 1992, pp. 120-121). Territorial and state government officials were not so powerless to stop either illegal settlement or illegal timber harvesting, but they were conflicted because settlement and logging activities were good for a territory’s economic and demographic development. Were it not for the miners and loggers, Wisconsin might never, or only much later, have become separated from Michigan as a territory and, subsequently, a sovereign state. Consequently, state officials had incentives not to strictly enforce the laws, including trespass, fraud, and breach of contract claims that could be strictly enforced in court. There were, however, some efforts in territories and states to control timber harvesting.

In 1836, and again in 1844, the Wisconsin territorial legislature created criminal penalties for illegal logging on lands dedicated (by the 1787 Northwest Ordinance) for education and internal improvements. The 1844 Act provided for sentences of up to a year in the county jail or \$500 (Hurst 2010, p. 87). In 1849, the US Supreme Court liberally interpreted an Act of Congress to make timber trespass a criminal offense when committed on the public domain (Ibid., p. 87). In 1882, the US Supreme Court ruled that timber illegally harvested from Oneida Indian tribal lands (technically, public lands of the United States) in Wisconsin constituted an enforceable trespass and granted damages. Finding that the trespass was willful, rather than accidental, the Court decided that the measure of damage should be the value of the fallen timber at market (rather than on the ground before transportation to a mill site). *E. E. Bolles Wooden Ware Co. v. United States*, 106 U.S. 432 (1882). The Wisconsin Supreme Court likewise strictly enforced an enhanced damages remedy created by statute (Hurst 1984, p. 86). Such cases might have disincentivized timber trespass, but clearly there were not enough such cases prosecuted to deter illegal logging operations.

Even in cases where logging companies lawfully purchased land – usually for pennies an acre – they cared not a whit about the land itself. Its only value for them was in the crop of trees it

contained. Once the trees were cut, no thought was given to replanting, which would be costly and time-consuming. It made much more sense simply to abandon the land, the title to which would revert to the territory or state for nonpayment of taxes (Hurst 1984, p. 83). None of this was technically illegal; no replanting or land reclamation requirements existed before the twentieth century. What was illegal was the means logging companies sometimes used to acquire rights to enter heavily timbered federal public lands under the 1862 General Homestead Act. Under that statute, a settler could acquire a federal patent (i.e., legal title) for up to 160 acres of land, if they occupied, resided on, and improved it for five years. Logging companies would sometimes pay third parties to sign fraudulent affidavits stating that they were good-faith settlers. There were far too many applications for federal government employees to carefully review even a fraction of them (Wilkinson 1992, p. 121)

In 1879, the Commissioner of the General Land Office estimated that “nine-tenths of the homestead entries in the Wisconsin pinery ‘were made for the purpose of stripping the land of its timber’” (Hurst 1984, p. 79). In this way, entire counties were not only stripped of their trees, but left hardly any voters behind (Ibid., p. 80). By 1898, counties in the northern part of the State of Wisconsin held title to more than a quarter of a million acres of denuded lands, which they could not sell (Hurst 1984, pp. 79, 84). By 1900, barely ten percent of cut-over lands in those counties had been converted to agricultural use. The rest remained barren, unproductive, and uninhabited. Even fifty years later, less than seven percent of those lands had been “improved” for farming (Hurst 1984, p. 435). Meanwhile, scarcely 10 percent of Wisconsin’s original northern forest was left intact.

The fact that territorial and state governments (and even the federal government) were conflicted about enforcing laws that would constrain logging activities, whether legal or illegal, did not stop politicians, reporters, and other observers from complaining about illegal timber harvesting, the generally lawless behavior of loggers, and the effects of logging on the landscape. In 1847, nearly 20 years before his landmark book, *Man and Nature; or, Physical Georgraphy as Modified by Human Actions* (1864), the founding father of American conservation Geroge Perkins Marsh called for better “management of our forest lands.” He deplored the “rage for improvement, represented by forest clearance for agricultural development (Quoted in Cox, p. 93). Ten years later, in a comprehensive study of declining fish populations in the Upper Midwest, Marsh did not blame agricultural development as much as deforestation of hillsides, which denuded watersheds allowing for more higher levels of sedimentation of rivers and lakes (Cox 2010, p. 94).

Other commentators at that time, though not as attuned as Marsh to the secondary ecosystem consequences, nevertheless deplored rampant deforestation. As early as 1819, the Frenchman François André Michaux undertook the first systematic study of American forests and found an “alarming destruction of the trees...” (quoted in Pisani 1985, p. 342). In the early 1920s, the American novelist James Fenimore Cooper expressed (through his fictional characters) deep concern about deforestation and the prospect of timber famine (see, e.g., Cooper 1823, 1827; Pisani 1985, p. 342). In 1860, Minnesota’s first governor, Alexander Ramsey, in his inaugural address, called for better stewardship of the state’s forest lands (Ibid.) In 1867, Wisconsin’s State Forestry Commission published a *Report on the Disastrous Effects of the Destruction of Forest Trees*, which called for conservation policies (Ibid.). In 1865, Frederick Starr, Jr. penned an essay on “American Forests: Their Destruction and Preservation,” which appeared in the *Report of the*



*Commissioner of Agriculture for the Year 1865*. The essay, reminiscent of Thomas Malthus's dismal predictions, warned of "an impending national danger . . . beyond the province of words to express," of increasing rates of deforestation under conditions of high population growth (quoted in Pisani 1985, p. 343). In the late 1870s, at approximately the same time that Pennsylvania Governor Hartranft warned that all his state's big trees would soon be gone, the US Secretary of the Interior Carl Schurz warned that, at the existing rate of consumption, the US would run short of timber to meet domestic needs within the next twenty years (Pisani 1985, p. 345). He was not the only prominent figure to warn of a coming "timber famine" (Cox 2010, p. 201).

These warnings and calls for conservation had little immediate effect on policy, but they were repeated and amplified often enough in the last decades of the nineteenth century to gain public currency, which ultimately led to action to end the wanton destruction of public (both federally-owned and state-owned) and tribal forests. By 1903, the Wisconsin legislature began enacting laws to create "forest reserves" (Hurst 1984, p. 572). By 1912, 1.5 million acres were enrolled in the program. These lands were not necessarily off-limits to loggers, but the state more actively and effectively managed them to prevent the kind of degradation that occurred elsewhere.

With the rise of the progressive-conservation and preservation movements – represented respectively by Gifford Pinchot and John Muir – in the 1890s, federal and state governments began to more effectively regulate timber harvesting on the public lands; and as more lands were privately homesteaded, they were better protected against trespass by loggers. According to Cox (2010, p. 361) America's last forest frontier, centered around Bend, Oregon only began closing in the 1920s. But that could never have been the same kind of forest "frontier" as those in Wisconsin and Michigan a few decades earlier, if only because of new, more effective (if only marginally) regulations.

In 1864, Congress had created the first federal nature reserve at Yosemite, California. Eight years later, it created the world's first "national park" along both sides of the Yellowstone River in Wyoming (extending into Southern Montana). The next year, Dr. Franklin Hough "presented a paper, 'On the Duty of Governments in the Preservation of Forests,' to the annual meeting of the American Association for the Advancement of Science (AAAS), held at Portland, Maine. The following day, the AAAS prepared and approved a petition to Congress 'on the importance of promoting the cultivation of timber and the preservation of forests.' They sought congressional action, but no legislation was passed for 3 years" (Williams 2005, p. 4). When legislation was finally enacted, it did not provide a basis for direct federal control of logging on public lands.

In 1891, Congress enacted a Forest Reserve Act (a.k.a., the General Revision Act), which authorized the president of the United States to set aside from the public domain (i.e., areas open to settlement, mineral exploration, grazing, etc.) "forest reserves." Within 10 years, 45 million acres of federally-owned forests received limited protection as "forest reserves," subsequently relabeled as "National Forests" In 1905, the US Forest Service (FS) was created in the Department of Agriculture to manage the growing number of National Forests (and grasslands) for "multiple uses," which include timber harvesting limited in accordance with the principle of "sustained yield." That the FS was situated in the Department of Agriculture was no accident, as its first administrator, Gifford Pinchot, made clear in saying that "To grow trees as a crop is forestry" (Wilkinson 1992, p. 129).

By 1910, total acreage under the agency's control had more than tripled, to 172 million acres. The NFS's mission was conservation oriented, in contrast to the preservation orientation of the National Parks, where no timber harvesting is allowed. Given its multiple-use mission, the Forest Service has always had critics on both sides arguing either that it sells too much or too little timber. The most important point, however, is that it actively manages publicly owned timber resources, in place of their open-access treatment during the heady frontier days.

Even more effective was New York State's 1895 constitutional amendment (Const. art. 7, § 7), which declared that:

'the lands of the state, now owned or hereafter acquired, constituting the forest preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall timber thereon be sold, removed, or destroyed.'

The various state and federal programs created to conserve (and in some cases, preserve) publicly owned forests from destruction beginning in the 1860s were an important (if overlooked at the time) signal that America's remaining forest frontiers would soon be closing (see Power 1996, p. 133). In 1893, the historian Frederick Jackson Turner famously declared that the American frontier was closed (Turner [1893] 1921, Ch. 1). Although he was not referring specifically to the forest frontier, he might as well have been. It certainly is not implausible to argue that the forest frontier had closed by the turn of the twentieth century or shortly thereafter, even if problems of illegal logging and over-harvesting lingered (they linger still). The rise of professional timber management, which Gifford Pinchot imported to the US from Germany, along with state and federal regulations, and even the consolidation of the forest-products industry all signified that the frontier days had passed. In 1893, Turner lamented the closing of the Frontier, which he held as a unique condition in the development of American democracy. But a generation later, he blasted "these slashers of the forest, these self-sufficing pioneers, raising the corn and livestock for their own need, living scattered and apart." (Turner \_\_\_\_). The problem was "no longer how to cut and burn away the vast screen of the dense and daunting forest" but "how to save and wisely use the remaining timber" (Ibid.) In effect, Jackson personified evolving public attitudes toward forest use and management.

Interestingly, precisely when the forest frontier was closing, American timber production was hitting a national peak. The Forest Service estimates that, in 1630, the US had 1,023 million acres of forests, covering approximately 46% of the total land area of the country. From then until 1910, primarily due to conversion of forests to agricultural uses but also because of bad logging practices prior to the twentieth century, total forest acreage was reduced by 296 million acres, a reduction of about 34 percent. Most of that forest destruction occurred in the second half of the nineteenth century, when an average of 13 square miles of forest was cleared every day for 50 years. Over the whole of the nineteenth century, American forests went from producing 0.5 billion board feet per year to producing more than 40 million board feet per year (see Williams 2003, p. 313; Laitos et al. 2004, p. 840). However, since 1910 total acreage in forests has remained stable, even rising slightly to 766 million acres, despite a tripling of the US human population (USFS 2015, p. 6).

That said, while reforestation efforts have increased the number of trees, they have not done much for the biodiversity of woodlands because much replanting has been of monocultures.

### **3. The Evolution of Deforestation at the Brazilian Frontier**

#### **The North-West frontier**

The story of Brazil's development of its frontier forests during the twentieth century is, to a significant extent, redolent of North American environmental history – at first blush Brazil appears to be replicating North American settlement policies and timber harvesting practices as they evolved during the nineteenth century.

In the 20<sup>th</sup> century, Brazil set out to further the integration of its Center-West (Cerrado savannas) and North regions (Amazon rainforests) within the national economy. It did so by designing policies and public agencies supporting the migration of people to these aforementioned spaces which were characterized by a low population density and were at geopolitical risk (especially in the view of the military dictatorship 1964-1985). This political transformation resulted in the exploitation of various natural resources in this frontier, including timber, rubber, minerals, and land (for cattle-ranching and agriculture), often turned toward exportation.

Within the northwest area of Brazil, it is possible to distinguish several “pioneer fronts” which followed distinctive pathways at different time periods. For instance, deep within the Amazon forest, the city of Manaus developed following the rubber booms of the late 19<sup>th</sup> and early 20<sup>th</sup> century and was turned into an industrial pole due to proactive government policies for most of the 20<sup>th</sup> century. The regions of Pará, Rondônia and Acre were colonized mostly after the military government took power and were characterized by cattle-ranching and the cultivation of perennials. The Cerrado savannas of the Center-West, which covers the states of Mato Grosso do Sul, Goiás and Mato Grosso, received the bulk of their migrants around the same time, but have a colonization history in multiple stages stretching back to the 1930s. Given the diversity of pioneer fronts available for study, we decided to focus our analysis on how the native vegetation of the Cerrado and areas bordering the Amazon biome was cleared for agricultural purposes. We decided so because this example of frontier captures the story of how a rapidly integrated region turned into a soybean powerhouse of global significance (Brazil became the first exporter of soybean in 2017). We focus on the state of Mato Grosso since it illustrates a greater diversity of land-uses and ecosystem conditions than the state of Mato Grosso do Sul and Goiás, which will offer interesting nuances to our interpretation of the institutional conditions in the frontier.

#### **Institutional conditions in Mato Grosso's frontier**

Throughout the 20<sup>th</sup> century, the North-West area of Brazil represented an “empty space” in the eyes of politicians and the military, despite the sparse presence of indigenous people (Oliveira, 2005). Holding such a space sharing a border with several other countries led to their perception that integrating it to the national economy was the only way to prevent it from being claimed by others in the future. President Vargas was the first to kickstart a vast movement of integration, when he famously outlined the “March to the West” plan on the national radio, on December 31, 1937 (Moreno, 1999). This first plan knew a slow start and first targeted the colonization of vast

areas of savannas and sparse forests of Mato Grosso do Sul and Goiás, in the Cerrado biome, and included the construction of infrastructure (roads) as well as the creation of agricultural colonies (Colônias Agrícolas Nacionais - CAN). Yet this first phase knew a mild success with few migrants moving into the targeted frontiers, despite the creation in 1946 of a constitutional fund for the development of the Amazon which set aside 3% of the state's budget to projects in the region (Le Tourneau, 2019).

Yet, the Cerrado and Amazon frontier already had several institutional conditions conducive to massive in-migration. Most of the land was public (*terras devolutas* in Portuguese), and any citizen settling on such areas could claim ownership of them as allowed by the 1850 Imperial Land Law. This possession right (*posse* in Portuguese). Such land claims were limited in size<sup>1</sup> and regulated first by the federal government, until 1891 when the Constitution operated the transfer of public lands from federal to state governments. Together with this change, states started selling land lots to any interested party as a way to generate revenue (Moreno, 1999). With the end of Vargas' *Estado Novo* period and the 1946 Constitution, states like Mato Grosso made land sales conditions more flexible with a view to increase the volume of land sales. Rivière d'Arc (1977) reports that in May 1960, the state of Mato Grosso had sold 1,918,334 hectares (ha) just in the northern area (Amazon biome), totaling 2,032,720 ha in the whole state. Yet such land distribution was marked by the corruption of public officials in distributing land, and acquisitions of land were dominated by speculators, both conditions resulting in a very low number of actual migration to the land lots sold.

Yet, starting in the 1960s, the state of Mato Grosso more actively promoted colonization through direct intervention. It created corporate entities in charge of organizing the colonization of large land lots over a few hundred thousand hectares. These *colonizadoras*, as they came to be named, were private companies in charge of recruiting migrants from southern Brazil, generally farmers, by selling them individual land lots in settlement projects around the state. These companies usually included the creation of a small town with basic services and participated actively in the planning of economic activities, by usually imposing a type of land use to migrant: cattle-ranching, the cultivation of perennials, or rice cultivation.

For example, in 1956, the *Colonizadora Noroeste Mato-Grossense S/A* (CONOMALI) obtained 240,000 ha of lands near the Arinos river, in Northern Mato Grosso, from the state. This *colonizadora*, like many others later, brought *sulistas* (i.e. colonizers from southern Brazil) from the states of Santa Catarina (SC) and Rio Grande do Sul (RS). They were almost exclusively small peasants of German origin and were invited to start coffee and rubber plantations in Mato Grosso. With very limited infrastructures (colonizers arrived and settled by the river, which was the easiest way to access this remote area of Mato Grosso), the project had limited success, and suffered from bloody encounters between colonizers and local indigenous tribes defending their encroached territory (Oliveira, 2005).

### **Shaping the frontier through (further) direct state intervention**

The arrival of the military dictatorship in 1964 changed the shape of state intervention and marked the beginning of massive migration in Mato Grosso's frontier – with its associated deforestation.

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<sup>1</sup> The size of land claims was limited to 25 hectares until 1951 in the state of Mato Grosso.

Starting in the 1970s, the military government created several funding lines for developing economic activities in the frontier (POLAMAZONIA, POLOCENTRO, etc.) and a set of development agencies in charge of organizing the funding of colonization projects for both the Amazon (i.e. SUDAM) and the Cerrado (i.e. SUDECO).<sup>2</sup> It created tax breaks and tax holidays for agricultural activities in the area (Mahar, 1979). The government also decided to re-appropriate public lands once transferred to states (at the end of the 19<sup>th</sup> century) by creating the National Institute for Colonization and Agrarian Reform (INCRA) in 1970 and empowering it with competence over all public lands situated within 100 kilometers of federal highways in 1971. The government also built or paved several highways to further the penetration of the state into the forest, the building of the BR-163 highway, linking Cuiaba (Mato Grosso state capital) to Santarém (2<sup>nd</sup> largest city in Pará state) being one of the most emblematic example of this.

*Colonizadora* projects organized around mining, cattle-ranching (sometimes agriculture) captured this financial assistance and started multiplying, especially in the northern areas of Mato Grosso. Yet, funds affected to agricultural projects in the 70s and 80s (around 40%) were overwhelmingly distributed to cattle ranching projects (Campari, 2005; Stella, 2009).

Concurrently, the Brazilian state started investing massively into agricultural research. Such efforts built upon an ongoing US-Brazilian scientific cooperation aiming at improving soil fertility in the Cerrado and developing commodity agriculture (soybean, rice beans, corn and cattle) (Nehring, 2016). Soybean stood out as the most suitable crop for the expansionist projects of the government, since it presented both a good marketing future and had nitrogen-fixing properties that helped economize the use of fertilizers. Public research, mostly carried out by research institutes later associated with the EMBRAPA (created in 1972), helped adapt soybean varieties to the acidic soils of the Cerrado, and address the challenge of different photoperiod in the lower latitudes of the tropics (which was required if agriculture was to expand further north) (Spehar, 1995; Wilkinson & Sorj, 1992). In 1973, the announcement by U.S. president Richard Nixon of an embargo on U.S. soy exportations provided the momentum for boosting the profitability of soybean cultivation in Brazil and paved the way for its subsequent expansion in the Cerrado up to the Amazon in Mato Grosso.

[Figure \_\_ on colonization policies – about here]

### **Agricultural expansion, extensive deforestation, and globalization of the frontier**

Mato Grosso's frontiers experienced a migration boom starting in the 1970s. In the north, swaths of migrants arrived from Southern Brazil to undertake mining or cattle-ranching. In the southern and center parts of the states, migrants oriented toward agricultural cultivation started planting rice, and quickly after, soybean. Soybean cultivation arrived as part of a wave of expansion that had already occurred partly southwest from there, in the states of Mato Grosso do Sul and Goiás. Yet, it is in Mato Grosso that soybean cultivation knew its greatest commercial expansion due to

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<sup>2</sup> Mato Grosso was ideally placed at the border of two biomes and within the Legal Amazon region, an administrative area defined in 1953 to define the scope of application of constitutionally-allocated funds to the region. It thus benefitted from multiple funding lines belonging to either the Center-West agency (SUDECO) and North agency (SUDAM).

the uniquely advantageous biophysical conditions present. Despite the poor infrastructure conditions (located 2,000 kilometers away from exportation ports of Sao Paulo and Curitiba), the center region of Mato Grosso became the principal producing region by the 1990s due to its abundant and steady rainfall season (6 months per year).

The area planted in soybean in Mato Grosso doubled in just ten years, between 1988 and 1998, increasing from 1.3 million (m) ha to 2.9 m ha, and doubled again in just six years between 1998 and 2004, going from 2.9m ha to 5.2m ha (IBGE, 2018).<sup>3</sup> This rapid expansion resulted in the extensive clearing of native vegetation, principally in the Cerrado biome, but started encroaching significantly on forests of the Amazon in the late 1990s.

The high levels of deforestation occurring in the Amazon region in the 1980s and 1990s in other frontiers (expansion of cattle-ranching) prompted a federal government response with the creation of the “Our Nature” program in 1988 (*Programa Nossa Natureza*). This plan mostly created a monitoring system for deforestation, but legal compliance measures were too weak to have any deterring effect on private landowners clearing land. Yet again, such landowners were limited by the land clearing limits established by the main environmental legislation in Brazil, the Forest Code (FC). The FC established that a minimum percentage of native vegetation was to remain intact on every rural properties in Brazil, with greater percentages applying to areas of forest in the Legal Amazon region.<sup>4</sup>

This policy reaction did not prevent extensive land clearing to occur as the frontier entered into a new phase in the 1990s with the disappearance of public funding support (due to the end of the military regime and the return of democracy in the mid-1980s) and the reinforcement of the role played by globalization and private actors. The arrival in the 1990s of multinational actors in the soybean frontier, filling the gap left by the government, fueled the soybean expansion and its orientation toward exports on world markets. The international demand for soybean was stimulated by the outbreak of the “mad cow” disease in Europe and the switch to soybean-based meals to feed livestock operations there (Nepstad, Stickler, & Almeida, 2006). As a result, soybean cultivation in the Mato Grosso frontier exploded in the 1990s throughout the mid-2000s.

### **Anti-deforestation policies and the intensification of agriculture**

Faced with unprecedented domestic and international pressures from environmentalist NGOs and the general public, the Brazilian government attempted at first to control the large-scale clearing of native vegetation occurring in the Amazon, leaving the Cerrado mostly unattended. With the creation of the Action Plan for Deforestation Prevention and Control in the Legal Amazon (PPCDAm) in 2004, the government cracked down on deforestation with military-like operations conducted by the environmental police (IBAMA), which were supported by a real-time deforestation monitoring system pioneered by INPE. These programs were furthered in the years following by their renewal and extension, but also by changing market conditions. The soybean

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<sup>3</sup> Just as a regional comparison, the area of planted soybean in the Center-West region (which encompasses Mato Grosso, Mato Grosso do Sul and Goiás) presented 3.3 m ha planted in 1988, 5.1m ha in 1998, and 9.7m ha in 2004. The majority of this expansion thus occurred in Mato Grosso.

<sup>4</sup> This is a simplification of how the FC's native vegetation requirement worked. For a full understanding of how these limits worked, please refer to Delaroche (2019).

sector was subject to consumer pressures (mostly from Europe) and food retailers started pressuring their Brazilian suppliers in not sourcing soy originating from recently cleared areas (creation of the Soybean Moratorium) (Nepstad et al., 2014). The slowdown of deforestation in the soybean frontier of Mato Grosso resulted from the combination of these forces, along with adverse economic conditions not conducive to the expansion of cultivation, such as the deterioration of the Brazilian real – U.S. dollar exchange rate (Assunção, Gandour, & Rocha, 2015).

#### **4. Comparing and Contrasting the “Forest Frontiers” of Brazil and the US**

The forest frontiers of Brazil and the United States undoubtedly present important contrasts in the way they unfolded. To start with, the former expanded at the 19<sup>th</sup> century starting during pre-industrialization times while the latter expanded in the 20<sup>th</sup> century, in a context of accentuated globalization of commodity trade. This temporal difference certainly had critical implications in the way pressure on resources occurred. In the United States, for instance, wood was at times high on demand for specific industries, like ship construction in Maine, and on moderate demand when simply supporting the building construction demand for long-term settlements of U.S. migrants. In Brazil, the frontier has known several boom-and-bust cycles depending on the commodity that was, most of the times, demanded by international markets (e.g. rubber in the late 19<sup>th</sup> early 20<sup>th</sup>, meat in the second half of the 20<sup>th</sup> century, and soybean cultivation in the late 20<sup>th</sup> century). The lure of rubber, mining, and wood products in the forest areas of the Amazon made migrants “skip over” entire regions that turned out (late 20<sup>th</sup> century) to be actually more profitable and sustainable due to soybean production. In Mato Grosso, migrants overlooked the Cerrado areas to do predatory uses in the northern part of the state, only to realize later that technological advances in tropical soybean cultivation made Cerrado areas more prosperous.

Secondly, the institutions put in place to close the frontier (i.e. regulate forest clearing), be it for logging or simply to replace the cover with another land-use, were different (and motivated differently) in each country. The U.S. preservationist and conservationist movements appeared at the peak of frontier expansion, culminating with the creation of the U.S. Forest Service in 1905 by President Theodore Roosevelt. In Brazil, the concern for forest preservation predated, in fact, the peak of expansion since the Forest Code, the main environmental legislation, was created as early as 1934.

In spite of their numerous contrasts, the U.S. and Brazilian forest frontiers presented important commonalities in their development. Both countries have experienced a change from colonial to sovereign power that reshaped the constitutional incentives of frontier expansion, mostly through incentives for spontaneous colonization. Brazil became independent on Sep. 7, 1822 and passed in 1850 the famous Land Law (*Lei da terra*) making public lands up for spontaneous settlement in most of the country. Interestingly so, the U.S. equivalent (Homestead Acts) appeared slightly later than the Brazilian Land Law. Both legislation embodied the bedrock of frontier ideology according to which development is better than no development, explaining perhaps the initial reluctance of these governments to regulate frontier areas tightly, both of which were characterized by unlawfulness until very late in their development (and still arguably is the current state of affairs some areas of Brazil).

Some of the ‘usual suspects’ played the same role in both areas. For example, infrastructures and biophysical conditions often conditioned human movements across the frontier. The absence of infrastructures other than waterways conditioned the way the rubber boom occurred in Brazil (concentrated on the borders of the Amazon river banks and its tributaries). In Brazil, 95% of deforestation occurred within 5.5 kilometers of a road (Barber, Cochrane, Souza, & Laurance, 2014). However, the role of road infrastructure is one that is ambivalent at best and has to be nuanced in light of the institutional factors underpinning (or surrounding?) it. In the U.S. some of the infrastructure development marked the transition of a region toward stable forest cover (e.g. Bangor, MN), perhaps making predatory uses go away. With respect to the aforementioned lawlessness of the frontier, infrastructure equally allows the presence of predatory use than it reduces them by allowing greater state presence and ultimately increasing (at least theoretically) the possibility of state enforcement.

On another note, biophysical conditions in both places mattered a great deal. Extreme cold winters conditioned the speed of deforestation in Michigan and Minnesota as much as tropical conditions (including acidic soils) prevented for a long time the expansion of commodity agriculture in the Cerrado and the Amazon. In both frontiers, biophysical and infrastructure conditions thus overly determined the pace of frontier development for extended periods of time.

Finally, the U.S. has known, and Brazil still experiences, a lengthy ‘closing’ of the frontier which involve the realignment of colonization incentives. It is unclear whether the first attempts to regulate illegal logging in the U.S., which mostly failed, were motivated by true resource overuse concerns or rather because they represented a missed opportunity of raising revenue for the state (let alone, to assert state control over an activity). Similarly, Brazil took a long time to effectively react to a phenomenon outside its control. The very high deforestation rates experienced by the Amazon in the 1980s simply led to formulating a plan and initiated the satellite monitoring program of deforestation, with no strong enforcement measures (in 1988). Quite paradoxically, it is a year after in 1989 that the Brazilian government felt obliged to specify that the Legal Reserve to be preserved on rural properties located in the Cerrado, which was experiencing swift land clearing and soybean expansion, was to be only of 20% of the property area.<sup>5</sup>

## **5. What Can Be Learned from This Comparative Analysis? Toward a General Hypothesis of the “Frontier” as a Definable type of Social-Ecological System**

This paper has examined “forest frontiers” in two different places over two different times periods, as if everyone involved with forest use and management understood what the term “frontier” meant at the respective times and is if readers of this paper understand its meaning in the context. A large literature exists on “frontiers” or “the frontier,” most of which focus on the term’s historical significance either as a “myth” (see, e.g., Furniss 1997/98) or as reality (see Turner 1893).

Our goal is somewhat different: to understand the “frontier” in terms of the literature on commons and inquire whether it has utility for the study of combined social-ecological systems. It would not be appropriate to draw hard conclusions from comparative case-studies of just two countries. But

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<sup>5</sup> Retrospectively speaking, it ended some uncertainty about the LR percentage in the areas of soybean expansion in Mato Grosso, for which it was unclear whether 50% or 20% had to be respected



based on comparable elements from the Brazilian and US forest frontiers, we can at least offer a general hypothesis, subject to further testing, of the “frontier” as a generalized *type* of social-ecological system with certain common institutional and ecological conditions.

### **The Concept of a “Frontier”**

The word “frontier” has been in use for more than three centuries in the United States (Mood 1948), usually to refer to boundary regions between settled and unsettled territories (as “settlement” is understood in the user’s social ontology). According to the Oxford English Dictionary (online edition), the use of “frontier” to reference a boundary between settled and unsettled areas is well-established. That definition retains currency not only for still-unsettled places in the world but is often colloquially used in reference, for example, to unsettled science on the “frontiers of knowledge.” Sometimes, the definition “frontier” becomes institutionalized, as in the US Census Bureau’s late nineteenth-century determination that the “frontier” is a place with a settled human population density of less than two people per square mile. It was that official definition that led Frederick Jackson Turner to declare in 1893 that the US frontier was closed (Turner [1893] 1921).

The frontier concept has been subject to further development since the nineteenth century, including in Brazil. The historian Pierre Monbeig (1952) sought to differentiate between (relatively) permanent frontiers, such as the borders between countries, and temporary frontiers, such as forests by referring to the latter as a “pioneer front.” Others have observed that colonization areas in the Amazon are marked by spatial discontinuity, since colonization settlements seem to present different degrees of advancement; they are not necessarily connected to one another or perfectly integrated with the rest of the country (Dubreuil et al., 2009; Le Tourneau, 2019; Théry, 1996). The concept of frontier has also been approached from the viewpoint of institutions. To be sure, Turner’s own view of the frontier was that it is a place that calls for “new institutions and activities” (Turner [1893] 1921: 38). To him, the American West was not just a different place, geographically but also socially and culturally.

Turner’s view of frontiers is not without its critics (see, e.g., Pierson 2002), but it has the singular merit of situating groups of actors – the frontiersmen – within what, in his view and ours, amounts to a specific kind of social-ecological system. Like Turner, we view frontiers not only as places but as sets of institutional and ecological conditions that lead to patterns of resource use (see the “Patterns of Interaction” box in Figure 4). Environmental resource consumption taking place at the frontier is a function of particular institutional conditions under which agents, including temporary loggers as well as more permanent settlers, operate. Common-pool resources in frontiers include land, forests, water bodies, wildlife, and minerals, and they are generally open to free access and use, regardless of formal ownership or regulatory arrangements because they are also *legal frontiers* – places where the law is as unsettled (which is to say, unenforceable) as the land.

Social-ecological conditions at the frontier mean that most (if not all) frontier resources are common-pool resources (CPRs), rivalrous in consumption with high costs of exclusion (see V. Ostrom and E. Ostrom 1977; E. Ostrom 1990). In that respect, the frontier presents a challenge to resource conservation over time. The goal of sustainable management implies that the frontier, as

such, must somehow, eventually be closed. Closure does not have to be immediate. So long as demand for resources is sufficiently low, relative to supply, open access may be the optimal policy (see Libecap 1989; Cole 2002). But as resources become scarce relative to supply at the frontier, then closure by some institutional mechanism(s) becomes necessary to avert a “tragedy of the commons” (Hardin 1968). Unless that happens, frontier resources will be degraded and eventually destroyed (a “tragedy of the commons”). The goal of frontier closure is sometimes to end resource use (i.e., preservation) but more often to attain a long-term sustainable rate of use (i.e., conservation).

Figure \_\_, below, is a first effort to describe a generalized “forest frontier” as a social-ecological system using the combined IAD-SES framework (see Cole, Epstein, and McGinnis 2019). The variables it contains are proffered as a set we predict would be common across many (if not all) frontier forests, regardless of location. This can be tested by reference to historical frontier forests from ancient Athens and Rome to the Scandinavian and Russian taiga, as well as modern forest frontiers, including (in addition to Brazil), China and other developing countries.

[Insert Fig. \_\_ IAD-SES analysis about here.]

Another question, more difficult to answer, is whether the notion of a “forest frontier,” or “frontier” more generally, implies a Rostovian Stages of Growth model or initial movement up the left side of the inverted “U” of an Environmental Kuznets Curve. An answer to that question is underdetermined by the information provided in this bilateral comparative analysis. However, from what we know about the closure of many forest frontiers in the modern era, from the US and Canada to Poland and Belarus, it seems at least plausible that the frontier is a temporary condition that arises where some valuable resource is so plentiful that it is difficult, at least at first, for inhabitants to perceive its boundaries. As the frontier’s boundaries eventually come into focus, efforts to conserve the resource begin, though whether or not they are successful – that is, whether the situation is a “resource curse” or a “resource blessing” – depends on many other factors relating to institutions and institutional change (see North 1991).

# The Shifting US “Forest Frontier,” Colonial Era to 1865

(After Cox 2010)

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Fig. \_\_\_

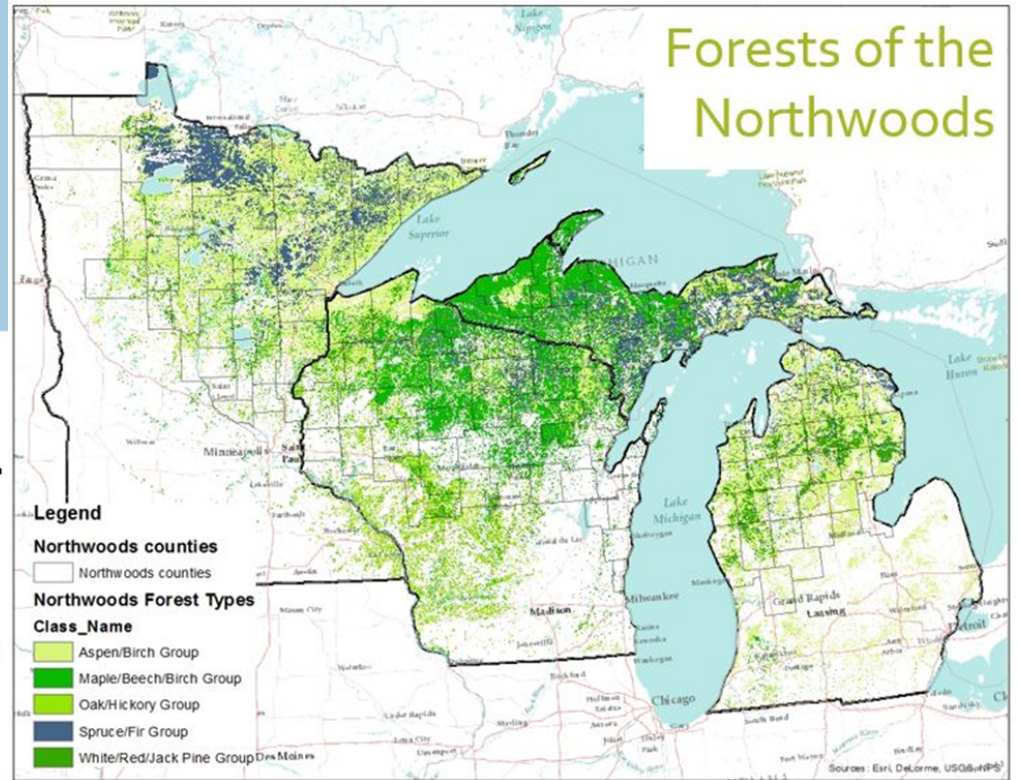
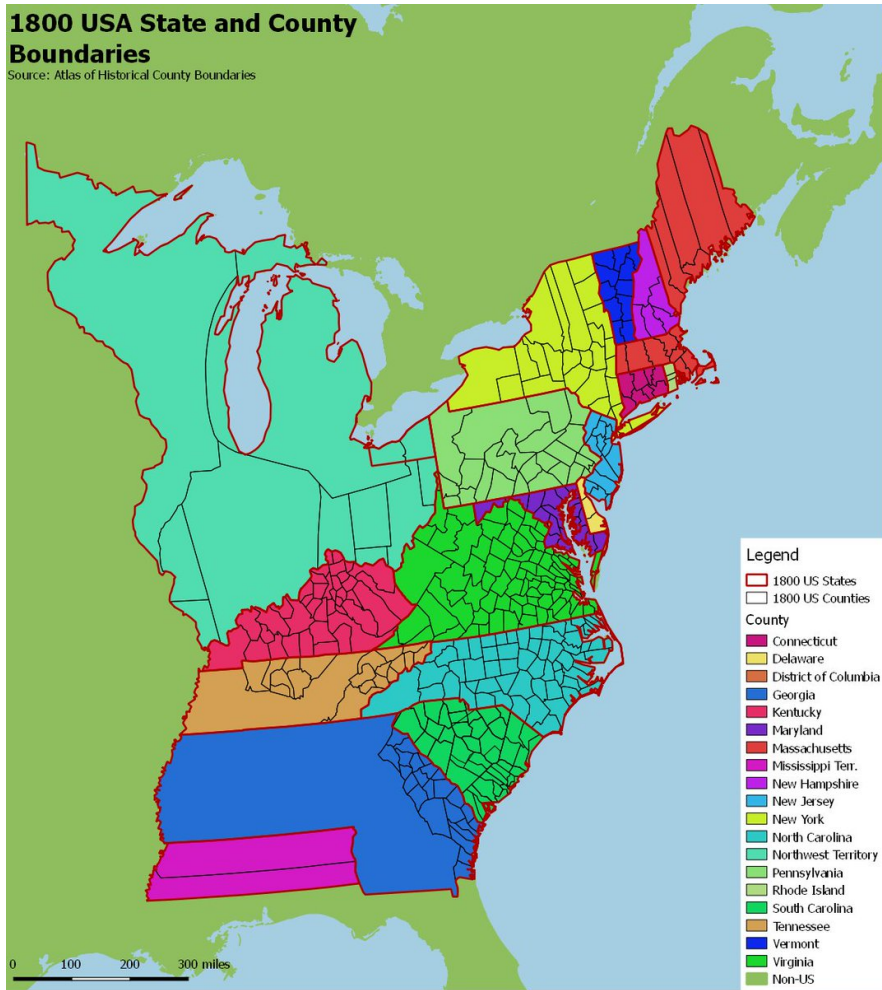


Figure \_\_. From the Upper Peninsula of Michigan, After Clearcutting

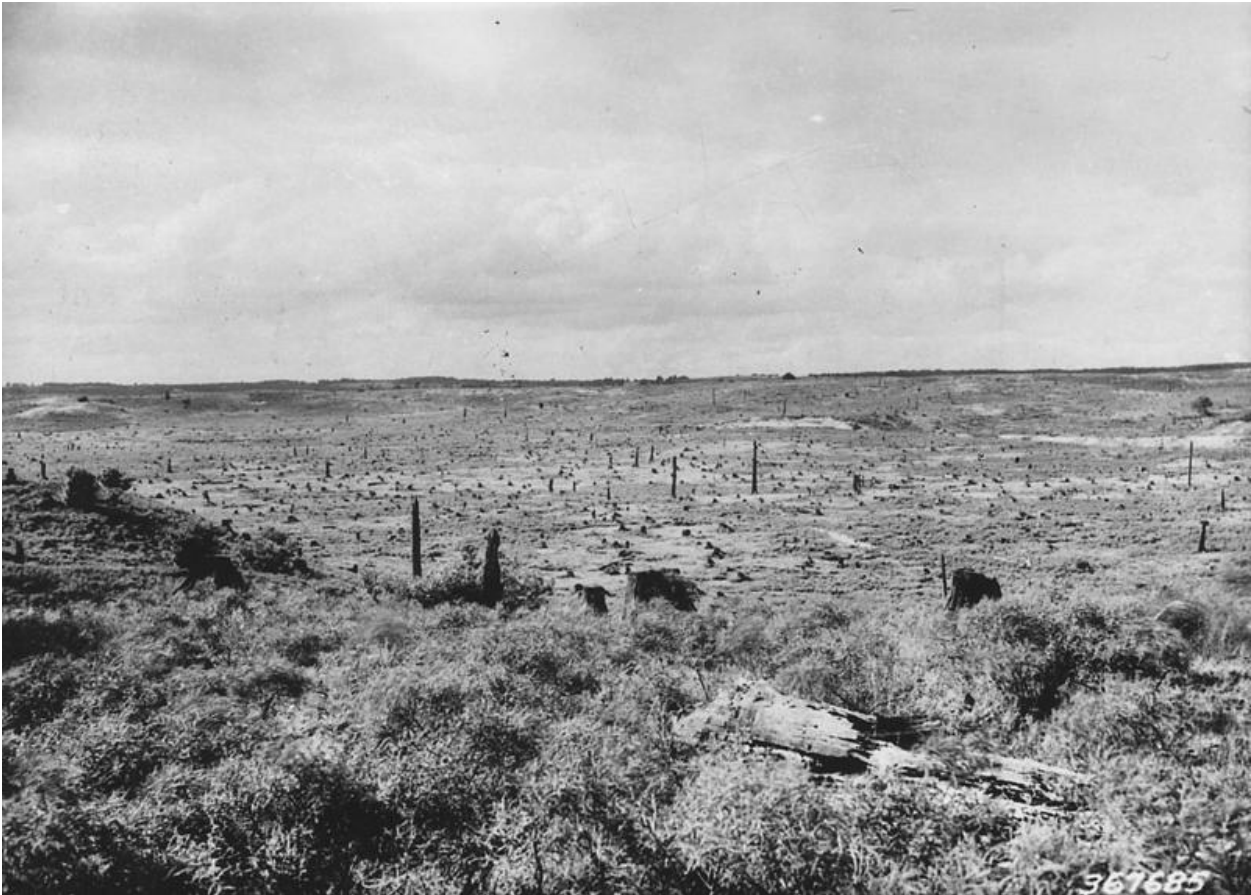
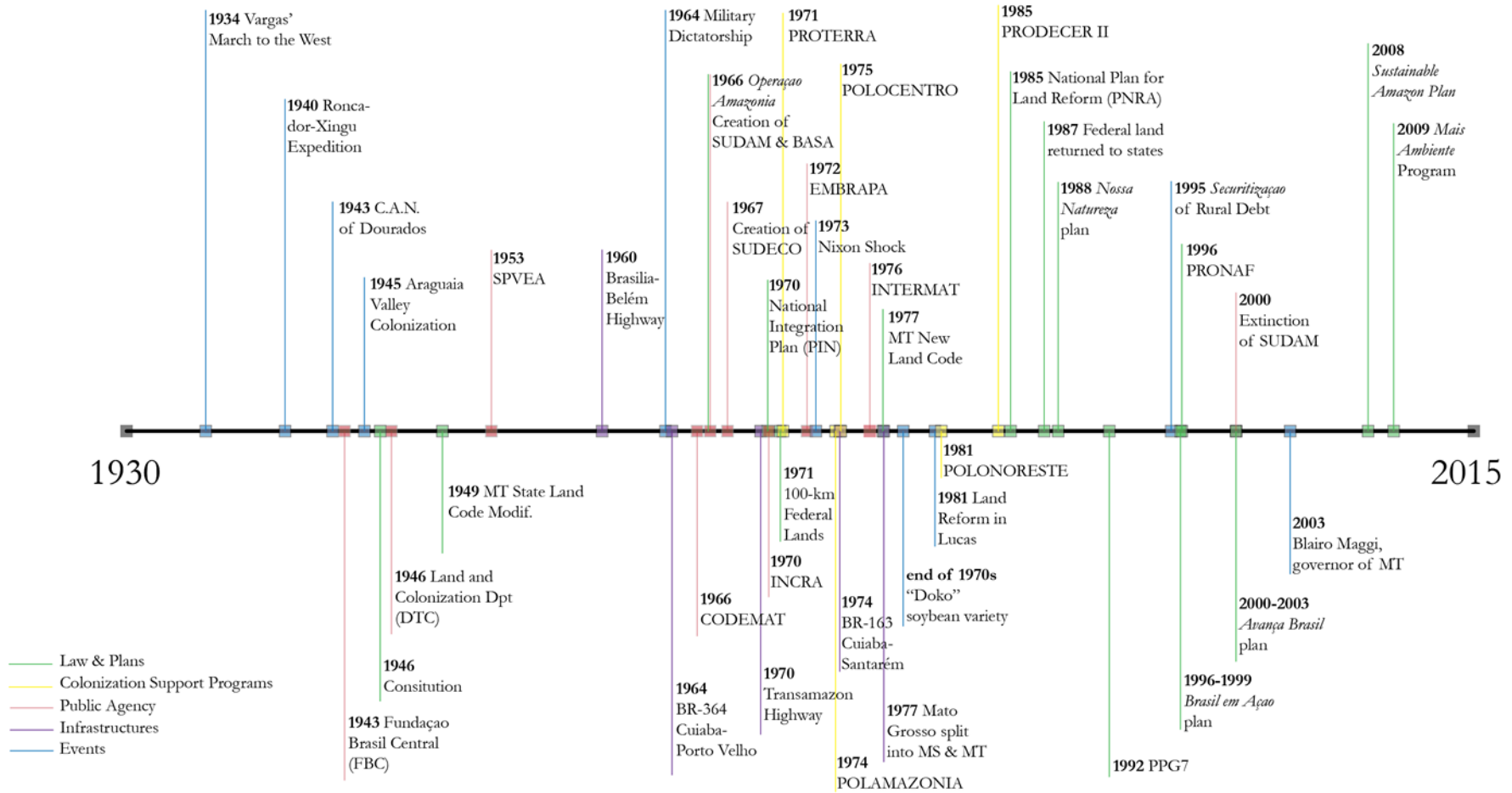


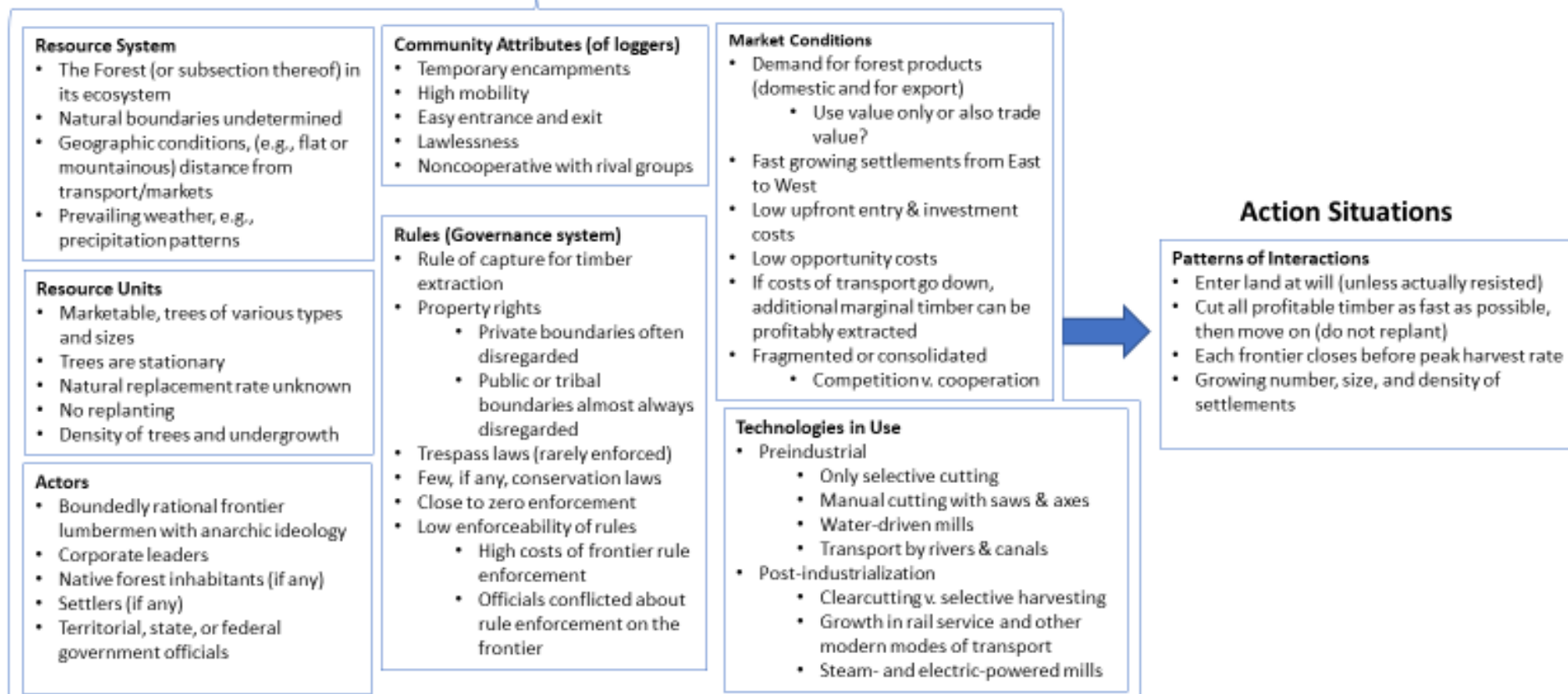
Fig. \_\_. Timeline of Amazon colonization

### Timeline of colonization policies and subsequent plans & programs relevant to the Legal Amazon



# Combined (Meta) IAD-SES Diagram of a Generalized “Forest Frontier”

## Preexisting Social & Ecological Conditions



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