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The social construction of pine forest wastes in southwestern France during the 19th and 20th Centuries

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For hundreds of years, pine forests played a crucial role in the economies of many western nations. The so-called 'naval stores', tars and pitches extracted from resinous pine wood, served for ship caulking, making international sea commerce possible since antiquity. The demise of wooden ships posed new challenges to the pine forest industry, but the versatility of pine products seemed infinite. Turpentine from pine resins became widespread as a lamp fuel in the middle of the 19th century, and later as a solvent competing with petroleum. Quick-growing pine trees were used for dimensional lumber, furniture wood, flooring, chemically treated utility poles, and various other products. The vast pine forests of the American South and Scandinavia were an excellent source of revenue. At the beginning of the 19th century, the French, seeing the potential value of the pine tree, started a forestation project with a local species, *Pinus maritima*, in the departments of Landes and Gironde in southwestern France. The French forest grew ten-fold, from 100 ha in 1800 to over a million ha in the first years of the 20th century. The Landes forest, the largest European forest massif, was a collective investment by the French state, local communities, and private individuals. It was intended to generate profits for decades and its full intensive exploitation was considered a priority. The forest was not merely a natural resource of a given raw material or substance anymore. It became a carefully managed asset to be fully exploited with no waste to remain unutilized. However, what exactly constituted 'waste' was highly conjectural and depended on environmental factors, the state of technology, and market needs. The wastes were defined through valorisation policies or, to put it differently, they were socially constructed, and their history can provide us with a novel perspective on the economic history of forests.

Interestingly, while the history of pine forests has been researched both in France[1] and in the United States (US)[2] and the topic of wastes as such did not escape environmental historians in general, with a rich and growing corpus of literature[3], forest debris has gained relatively little attention as an autonomous topic on its own. While the challenges posed by wastes are of course identified by forest historians[4], only a few authors ventured in constructing a more theoretically-driven approach on forest wastes and their role in the shaping of forest spaces.[5] The reason for this might be a notorious difficulty in defining the notion of waste. The history of sustainability practices shows that seemingly non-productive parts of the forest played a significant role in maintaining the economic life of local communities for centuries.[6] The binary logic product/waste is a recent one. As Tim Cooper puts it: "Modernity produces waste, but without waste on which to operate there is also no modernisation. The idea of 'waste' thus involves a dialectical symbolic process in which there is a simultaneous production of that which must be disposed of. Waste is not to be seen, therefore as merely the material product of industrial development (…). It was also bound up with, and enabled, the imaginary elimination of all that was defined under its aegis as either 'useless' matter, 'inefficient' practice or empty space. Anything named 'waste'

[1] Jacques Sargos, *Histoire de la forêt landaise: du désert à l'âge d'or* (Bordeaux: L'Horizon chimérique, 1997); Roger Aufan and François Thierry, *Histoire des produits résineux landais* (Arcachon: Société Historique et Archéologique d'Arcachon et du Pays de Buch, 1990). For a more general overview of the history of French forests see: Martine Chalvet, *Une histoire de la forêt* (Paris: Editions du Seuil, 2011); Musée de l'histoire de France, *Histoire de forêt : la forêt française du XIIIe au XXe siècle* (Paris: Adam Biro, 1997).

[2] Robert Outland, *Tapping the Pines* (Baton Rouge: Louisiana State University Press, 2004); Lawrence S. Earley, *Looking for Longleaf: The Fall and Rise of an American Forest* (Chapel Hill: University of North Carolina Press, 2005). Mason C. Carter, Robert C. Kellison and R. Scott Wallinger, *Forestry in the U.S. South: A History* (Baton Rouge: LSU Press, 2015).

[3] For an overview see: Tim Cooper, "Recycling Modernity: Waste and Environmental History", *History Compass*, 8/9 (2010): 1114 - 1125.

[4] See for example: Michael Williams, *Americans and Their Forests: A Historical Geography* (Cambridge: Cambridge University Press, 1989); Frederica Bowcutt, *Tanoak Tree an Environmental History of a Pacific Coast Hardwood* (Vancouver: University of Washington Press, 2015); Brett Bennett, *Plantations and Protected Areas: A Global History of Forest Management* (Cambridge: The MIT Press, 2015); Charles Watkins, *Trees, Woods and Forests: A Social and Cultural History* (London: Reaktion, 2014).

[5] Nancy Langston, *Forest dreams, forest nightmares: the paradox of old growth in the Inland West* (Seattle: University of Washington Press, 1995). See notably the section "Redesigning the Forest: Eliminating Waste and Insects" p. 148-156.

[6] For a general overview see: Paul Warde, *The invention of sustainability: nature and destiny, c. 1500-1870* (Cambridge : Cambridge University Press, 2018); For a more focused study on the French and their relationship with forest resources see: Kieko Matteson, *Forests in revolutionary France: Conservation, community, and conflict 1669-1848* (New York: Cambridge University Press, 2015).

becomes potentially subject to practices of disposal, recuperation and revalorisation."[7] Modernity divided the forest into a productive and a non-productive part ignoring the pre-modern experience and practices that had considered forest spaces in a more holistic way. Moreover, the forest industry exploiting the productive parts of the forest produced also new wastes directly linked to industrial techniques, leading the notion of 'forest waste' to acquire yet another layer of meaning. The purpose of this paper is to explain how forest debris and forest industry wastes function at the margin of forest economic imaginaries; it is not yet a raw material, but a potential one. The paper's goal is to show that categories like forest waste are intrinsically linked to scientific and industrial ones and are subject to continuous alterations and shifting cultural values. The article explores the plurality of the meanings of the term, reflects on its evolution, and tries to show that the term 'forest waste' can constitute an excellent measure of the degree of the understanding of the forest productive potential by exploiting industries. At least three influences seem to direct transformations of its meaning: socio-economic (a waste in one forest may be a useful raw material in another one due to differences in exploitation culture or in the structure of the industry), political (things become wastes when people realize that they remain unexploited, often when a political decision is taken to focus on a given market outlet), and scientific (scientists may 'create' new wastes by shaping expectations of the industry about the forest in order to construct their own epistemic authority).

The dialogue with sustainability studies explains the paper's focus on pine trees. The pine trees are an example of the so-called flex crops[8] and flex-trees[9], commodities whose success and persistence on the market is explained by the multiplicity of their uses. While flex crops, whose products can conquer different markets, contribute to the diversification of the offer of the processing industry, 'flexing' also leads to the decrease of biodiversity with one species replacing its less flexible competitors. Forestation with conifers is one of the most enduring forest policies continuing through the 19th and the 20th century in

[7] Cooper, 2010: 1120.

[8] Saturnino M. Borras Jr., Jennifer C. Franco, S. Ryan Isakson, Les Levidow and Pietje Vervest, "The rise of flex crops and commodities: implications for research", *The Journal of Peasant Studies*, 43 no. 1 (2016): 93-115.

[9] Markus Kröger, "The political economy of 'flex trees': a preliminary analysis", *The Journal of Peasant Studies*, 43 no. 4 (2016): 886-909.

France.[10] Pines' importance continued to grow as they penetrated more and more diverse market niches thanks to numerous properties of their wood and resin, but also thanks to the shifting perspective on what is a pine product and a pine waste. Studying pine wastes is a way to understand the tree's flexibility but it may also illustrate broader theoretical challenges concerning the place of wastes in forest spaces and their impact on sustainability.

For the sake of clarity, in this paper the focus is on a single case study, namely the French pine forest in the region of Landes. Because of its artificial origin, it is a paradigmatic case of a managed forest whose productivity was, and still is, constantly at the heart of political discussions. Moreover, the Landes forest was a terrain of studies of the Pine Institute in Bordeaux, a scientific-industrial research center established to create and improve market outlets for pine resins and pine wood.[11] The Institute's chemists were at the forefront of industrial considerations concerning the forest and actively participated in discussions surrounding its new potential uses. Because of its clearly delineated geographical area and a well-defined research infrastructure, the Landes forest constitutes a more approachable object of inquiry than American pine forests, where the industry and the research focus were much more fragmented. However, the French and American pine forest industries interacted for decades and their intertwined history will be discussed.

This case study covering the 19th and 20th centuries explores six different forest waste topics (rosin, stumps, forest debris, sawmill wastes, bark/cones/needles, and paper mill waste) and three primary influences (socio-economic, political, and scientific research) are used for analysis. The first section is a comparative analysis of two forest products/wastes in the US and in France: rosin and pine stumps. Its goal is to show that the notion of forest

[10] Vincent Moriniaux, *Les Français face à l'enrésinement : XVIe-XXe siècles*, PhD Dissertation in Geography defended at the Université Paris-Sorbonne (Paris: 1999).

[11] This paper is limited to pine wastes. For a more robust treatment of the history of the Landes pine forest and its place in the French and global industry see: Marcin Krasnodębski, *L'Institut du Pin et la chimie des resines en Aquitaine (1900-1970)*, PhD dissertation defended at the University of Bordeaux (Bordeaux: 2016); Marcin Krasnodębski, "A Tale of Two Forests: Knowledge Circulation between French and American Naval Stores Chemistry, 1900–1970", *Agricultural History*, 92 no. 4 (2018): 541-568; Marcin Krasnodębski, "National Fuel and National Forest: the French Quest for Wood Fuels in the Interwar Period", *Technology and Culture* (accepted). Another paper extensively discussing the forest's environmental history is a part of the official report for the French environmental research institute, IRSTEA, and is available on demand: Marcin Krasnodębski, "Challenging the Pine: Epistemic Underpinnings of Techno- Environmental Inertia". It is currently under review for publication.

products must be, first and foremost, analyzed locally as the practices can profoundly differ between regions. The second section discusses how the French national energy priorities between WWI and WWII transformed narratives on forest debris in the Landes. Its ambition is to demonstrate interconnectedness of different factors in evaluating the usefulness of a given forest waste. The third and final section draws attention to the importance of scientific research and, more importantly, of scientific narratives in shaping the notion of forest waste. It briefly presents the origins of certain research themes in the interwar period and then explores the limits of the narratives of French scientists in the 1970s and after. Each section uses different sources and analytical approaches. I explore the archives of the Pine Institute, the French professional (*Bois et Resineux*) and scientific (*Bulletin de l'Institut du Pin*) press, a rich secondary literature on the history of forests and of chemistry, as well as numerous private documents acquired from the former foresters and scientists throughout the project. The methods of approaching these documents are equally diverse, but can be broadly inserted into Fran Tonkiss' discourse analysis approach that focuses on salient elements of the narrative to reconstruct the broader meaning of the stories that are being told.[12]

[12] Fran Tonkiss, "Analysing discourse", in: Clive Seale (eds.), *Researching Society and Culture*, p. 245 - 260 (London: Sage, 2004).

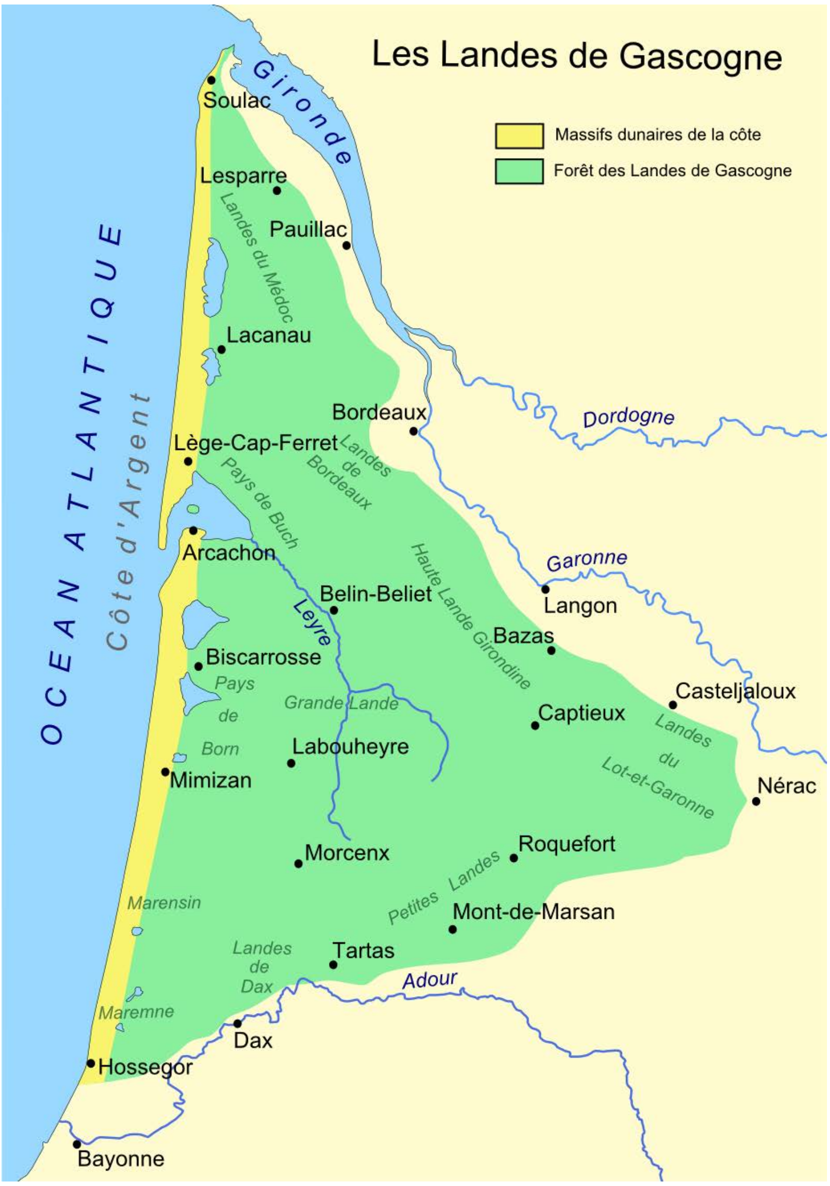

Figure 1: Landes of Gascony in France. In green, the area covered by the forest. Source: Cabaussel, 2006 (Larrousiney) [CC BY - SA 2.5 (http://creativecommons.org/licenses/by-sa/2.5)], via Wikimedia Commons.

1. American and French approaches to by-products of resin harvest

A. Rosin

In order to extract resin from a pine tree, it is necessary to remove a piece of bark and a thin film of wood to create a wound a few inches-wide, called the ‘face’. Pine resin appears on the face and slowly flows into clay cups (at present, special plastic bags are used). The wound has to be regularly renewed and enlarged to ensure a continuous resin flow. Every few days, forest workers are required to empty the cup and transport resin to distilleries. While some techniques have evolved, the principle of the pine tapping method has remained the same over the last two hundreds of years. Throughout the 19th and 20th centuries, the resin was distilled into volatile turpentine made of terpenes, corresponding to around 20 per cent of resin weight, and solid rosin made of resinic acids, corresponding to about 70 per cent. Turpentine had many different uses. In the first half of the 19th century in the US, it was used as a fuel for turpentine lamps[13], but above all it was, and still is, a high-quality solvent used by various industries, in particular, the paints and varnishes industry.[14]

From the 1920s/1930s, rosin was used for manufacturing gums, plastics, road coatings, varnishes, and many more products. However, in the first half of the 19th century, its uses were very limited. Highest quality bright rosins were occasionally used in soap-making, but darker, less valuable ones, had almost no immediate outlets. The problem was exacerbated in the US by destructive forest harvesting practices. The industry profiting from vast natural pine forests in the American South, unlike the French industry, was less interested in preserving natural resources that appeared to be inexhaustible in the industry's early days. On the contrary, the pines in the US were tapped to death and after five or six years of intensive exploitation, the trees could not regenerate. The industry sold timber and moved to yet untapped forests, leaving behind thousands of acres of dead pine stumps.[15] As a result of this intensive exploitation, the industry was continuously on the move, starting from North Carolina and descending throughout the 19th century first to South Carolina and then to Georgia and Florida. With a rudimentary road network in the vast southern woodlands, the transportation of final products outside the forest was economically viable

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[13] Outland, *Tapping the Pines*, 38.

[14] Marcin Krasnodębski, "A Tale of Two Forests: Knowledge Circulation between French and American Naval Stores Chemistry, 1900–1970", *Agricultural History*, 92 no. 4 (2018); Marcin Krasnodębski, *L'Institut du Pin et la chimie des resines en Aquitaine (1900-1970)*, PhD dissertation defended at the University of Bordeaux (Bordeaux: 2016).

[15] F. P. Veitch, "What Uncle Sam Does for the Naval Stores Industry", in Thomas Gamble (eds.), *Naval Stores: History, Production, Distribution and Consumption*, 135-138 (Savannah: Review Publishing & Printing Company, 1921); Thomas Gamble, "Charleston's Story as a Naval Stores Emporium", in Thomas Gamble (eds.), *Naval Stores: History, Production, Distribution and Consumption*, 35-36 (Savannah: Review Publishing & Printing Company, 1921).

only for the most expensive ones, meaning that only the brightest high-quality rosins could compensate for the costs. In practice, early turpentine manufacturers had no use for rosin and did not know of potential market outlets. More often, they considered it to be a wasteful by-product of turpentine distillation; it was not a commodity but an encumbering problem. As a consequence, the American turpentine distillers discharged rosin into channels that connected distilleries with streams, rivers or lakes, or simply into the holes near the manufacturing sites to get rid of it.[16] Operating in largely uninhabited areas, pollution was not widely perceived as a problem in the middle of the 19th century by the key figures of the industry.

Throughout the early 1800s, rosin accumulated on river and lake beds, often creating impressive deposits. However, in the second half of the 19th century, rosin prices started to slowly grow. Its use for paper sizing (making the paper more resistant to humidity) became more and more popular and new applications appeared, such as linoleum production, that could absorb even the low-quality dark rosins. The perspective on rosin slowly changed and it came to be considered, not a wasteful by-product of turpentine distillation, but an interesting raw material on its own. Its growing price led more and more industry leaders to ponder the exploitation of existing rosin deposits which had accumulated over decades at the bottom of lakes and rivers, since, under the water, the properties of rosin were preserved and it could be successfully harvested. The first rosin mine was most likely established in Angier, South Carolina, by a Sherman's army soldier just after the end of the Civil War.[17] This was the start of a true pine gold fever in the search for rosin deposits and in the following years many lakes were drained to exploit this new interesting 'mineral', but the entire enterprise did not last long. By the 1930s, most of the known deposits had been depleted, the last years bringing about the most spectacular and expensive rosin harvesting initiative: just after World War I, in 1920, when the rosin prices rose significantly, a certain Percy L. Gardner alongside with his brother built a dam around the rosin-rich part of Lake Catherine in North Carolina. After pumping out the water and drying and clearing the

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[16] Thomas Gamble, "Mining for Rosin in the Old North State", in Thomas Gamble (eds.), *Naval Stores: History, Production, Distribution and Consumption*, 37-39 (Savannah: Review Publishing & Printing Company, 1921); Outland, *Tapping the Pines*, 158.

[17] Outland, *Tapping the Pines*, 159.

bottom of the lake, they organized a massive harvesting project which involved tens of labourers mining the precious substance.[18]

View from Coffer Dam, Looking Across the Rosin Mine or Pit, Where Ten Feet of Water has been Pumped Out

Figure 2: A rosin mine at the bottom of lake Catherine.

Source: Thomas Gamble, "Mining for Rosin in the Old North State", in Thomas Gamble (eds.), Naval Stores: History, Production, Distribution and Consumption, 37-39 (Savannah: Review Publishing & Printing Company, 1921).

This shift in the perception of rosin, its transformation from a waste into a fully-fledged raw material for the industry was, however, an exclusively American phenomenon. The French forest industry followed a significantly different trajectory. The French pine forest was not 'natural' but plantations in a swamp-like region inhabited by sheep herders. The forest was intended to become their new home, a part of the local natural and economic landscape, as well as a long-term source of revenues for the forest owners and the local communities.[19] This goal required an approach radically different from the American one in terms of forestry and environmental management. First of all, the pine trees were tapped in a way that did not kill them. The American pine usually died after five years of

[18] Gamble, "Mining for Rosin in the Old North State", 37-39.

[19] Sargos, *Histoire de la forêt landaise: du désert à l'âge d'or.*

intensive exploitation, while the French trees could produce resin for up to 70–80 years with appropriate methods (even though less rewarding in the short-term).[20] The forest itself was considered an investment that was supposed to pay back and, therefore, its owners, as well as the local communities, were more eager to commercialize even less valuable forest products such as rosin. Rosin deserved special attention for another simple reason. Since distillation stills did not have to move regularly and were more integrated into the local socio-economic infrastructure, the pollution was a much more sensitive issue, unlike in the US where the distilleries were installed in barely inhabited regions. As a consequence, there was an imperative to find market outlets for rosin.

The French solution to the problem of rosin consumption had a few components. The first major difference between the French and American rosins was their quality. The French rosins were considerably brighter than the American ones, thus more valuable.[21] This is due to different resin treatment methods. The French, before distillation, heated the resin to the temperature of around 70 °C and filtered it to remove bark, insects, and other impurities. Again, this procedure required different installations and made the entire pine gum treatment process longer. As a consequence, it was less adapted for the American industry which was always 'on the move' and interested in fast profits. In addition the circulation of traditional know-how between the industries in the two countries was very limited in the 19th century, and the use of this technique was for a long time an exclusively French phenomenon. Light rosins obtained using the French technique were usable in soap-making, as an alternative to fatty acids. There was a second major reason for rosin's success in France. While in the US soap makers used, first and foremost, animal fat and the first soap

[20] It is important to note that scientific forestry had a much longer tradition in France than in the United States. It was Gifford Pinchot, the first Chief of the United States Forest Service, who studied at the French National School of Forestry and introduced the discipline to the US in 1890. At the turn of the centuries, the exchanges between the two forestry communities intensified, also concerning pine forestry. Charles Herty, Pinchot's contemporary and one of the fathers of the American chemical industry, visited the Landes forest in the early 1900s and was one of the key promoters of the French resin industry practices in the pine forests of the American South. See: Marcin Krasnodębski, "A Tale of Two Forests: Knowledge Circulation between French and American Naval Stores Chemistry, 1900–1970", *Agricultural History*, 92 no. 4 (2018): 541-568.

[21] Georges Brus, Pierre Legendre, "Essence de térébenthine et dérivés", in Georges Champetier, Henri Rabaté (eds.), *Chimie des Peintures, Vernis et Pigments,* volume II (Paris: Dunod, 1956).

businesses emerged near slaughterhouses,[22] in France the famous Marseille soaps traditionally used olive oil.[23] There was, in other words, a certain amount of know-how concerning the use of vegetal substances in soap making in France that was lacking in the US. As early as 1844, the French government supported exports of pine resin soap and, from the 1890s, rosins were often incorporated into the expensive Marseille soaps as well.[24] In the region of Landes, rosin soaps were equally popular for domestic use.[25] Again, the American industry which operated in scarcely populated areas could not develop this outlet that was linked to community life.

Another major outlet for rosins in the Landes region was due to a French pharmacist, Etienne Dive, from Mont-de-Marsan, a town located today in the middle of the forest. In 1822, he patented a technique for distilling rosin into greasing oils.[26] Over the years, these oils found multiple uses as lubricants, but also in varnish production (as a linseed oil substitute), or as an insecticide and disinfectant, important in the wine-producing region north of the Landes. Dive's pharmaceutical expertise combined with local know-how to transform a former forest waste product into something of commercial value, encouraging at the same time a more careful and sustainable exploitation of the forest resources, as they were to serve in the industry for the generations to come.[27]

Both rosin soaps and rosin oils emerged in France thanks to close links that existed between the pine industry and local communities, a synergy absent in the US because of the industry's mobile and destructive character. In France, rosins were never considered as waste, strictly speaking, but an additional pine forest product. In the US, in contrast, their role transformed radically, evolving from a waste to a valuable asset over a few decades.

[22] Richard L. Bushman and Claudia L. Bushman, "The Early History of Cleanliness in America", *The Journal of American History*, 74 no. 4 (1988): 1213-1238, 1235

[23] Roger Lebland, *Le savon: de la préhistoire au XXIème siècle*, (Montreuil-l'Argille: Éd. Pierann, 2001).

[24] Portmann, "Le savon de résine", *Bois et Résineux*, 14 August 1932.

[25] For more details on resin, pines, health and hygiene see: Marcin Krasnodębski, *L'Institut du Pin et la chimie des resines en Aquitaine (1900-1970)*, PhD dissertation defended at the University of Bordeaux (Bordeaux: 2016). See especially pages 152 and 153 (turpentine spirit) and 460-470 (soaps).

[26] Maurice Vèzes, Georges Dupont, *Résines et Térébenthines*, (Bordeaux: J.-B. Baillière et fils, 1924), p. 461.

[27] The place of chemistry in agriculture and its impact on the practices of sustainability throughout the 19th century were addressed by Paul Ward. See: Paul Warde, *The invention of sustainability: nature and destiny, c. 1500-1870* (Cambridge : Cambridge University Press, 2018), especially pages 297-307.

Interestingly, a similar evolution concerned another product of the American destructive forest utilization practices: pine stumps.

B. Pine stumps

The American naval stores industry, as previously explained, moved from North to South, exploiting pine trees to death. After a tree died, it was cut down for lumber. What was left behind were thousands of hectares of dead pine stumps. This was not only wasteful but also problematic for farmers who wanted to settle down. The trunks had to be removed before the area could be used for arable farming. Yet, this extraction was expensive and it became important to find some uses for this dead pine wood to cover the costs. One of the interesting properties of dead pine stumps is that they can accumulate a substantial amount of resin after spending many years in the ground. This resin could provide a solid source of revenues with a proper extraction method. In the late 19th century, some American companies started experimenting with the destructive distillation of wood from stumps, old branches, roots, and other wood wastes. Pinewood pyrolysis is, of course, an ancient method used for the manufacture of charcoal and pitch, but in the end of the 19th century it was discovered that it could lead also to more valuable acetone and methanol, as well as many resinous materials, such as dark rosins or even turpentine, that could be later sold on the naval stores markets. In practice, however, the yield was not satisfactory and the quality of the products very poor.

Homer T. Yaryan (1842–1928), an American engineer and entrepreneur, considered that destructive wood distillation was obsolete and extremely wasteful and he sought out alternatives.[28] In the late 1910s, he established an experimental wood treatment plant in Toledo, Ohio to test a novel technique. It consisted of treating wood chips with hot steam and then with mineral solvents. The steam mixed with turpentine spirit in the resin present in the wood, and then condensed turpentine was gathered into special recipients. The mineral solvents, on the other hand, allowed the extraction of rosin. This so-called 'wood distillation' gives, as a consequence, the same products as resin distillation, namely

[28] V. R. Crosswell, no title, 18 octobre 1951, Naval Stores History 5/4, Hercules Inc. Series III - Public Relations-1, box 5., Chemical Heritage Foundation, Othmer Library (Philadelphia).

turpentine and rosin, and in similar proportions, even though their composition slightly differed.

Yaryan established two factories, one in Gulfport, Mississipi in 1910 and one in Brunswick, Georgia in 1911, but numerous technical difficulties, as well as unsatisfactory quality of the end products, hindered the expansion of his company. One of the major difficulties was still the prohibitive costs of extracting pine stumps.[29] Because of its economic importance, the issue came to the attention of the national authorities. In 1918, stumps covered around 76 million acres in the American South, with 10 million acres added every year due to destructive practices of the American pine industry.[30] The Department of Agriculture understood the problem and also the agricultural potential of this area and encouraged private businesses to find cheap ways of clearing the land to facilitate farming. The most cost-effective method of extracting pine stump was the use of explosives. With the support of the US Department of Agriculture, Hercules Powder Company, one of the American chemical giants, was at the forefront of the activity and quickly became interested in the potential of the pine stump business in general. Impressed with Yaryan's wood distillation methods, Hercules acquired Yaryan's distilleries and started constructing its own plants from 1920 onwards.[31]

Even though the business was sluggish at first, scientific research funded by Hercules throughout the 1920s and 1930s greatly improved the quality of the wood naval stores (as opposed to gum naval stores extracted directly from resin). Wood turpentine and wood rosin, of similar quality but cheaper than their gum counterparts, quickly conquered new markets. Many companies followed Hercules' footsteps and the production of wood naval stores surpassed gum naval stores by the middle of the 1940s.[32] Dead pine stumps, that seemed inexhaustible in the interwar period, were at the heart of this revolutionary change. What was an encumbering forest by-product a few years earlier, turned out to be the main

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[29] Crosswell, no title, 1951.
[30] Editorial, *Mixer*, March 1920, Naval Stores History 5/4, Hercules Inc. Series III - Public Relations-1, box 5, Chemical Heritage Foundation, Othmer Library (Philadelphia).
[31] Editorial, *Mixer*, March 1920, Naval Stores History 5/4, Hercules Inc. Series III - Public Relations-1, box 5, Chemical Heritage Foundation, Othmer Library (Philadelphia).
[32] Duane F. Zinkel, *Naval Stores, Production, Chemistry, Utilization* (New York: Pulp Chemical Association, 1989), p. 50; Naval Stores Review International Yearbook, (New Orleans: 1948).

raw material for a rapidly growing industry. Destructive, unsustainable forest exploitation practices could ironically lead to lucrative industries at a later date.

However, the French could not profit from pine stumps. Due to sustainable practices, pine trees in the Landes forest could live for decades; there were no 'pine stump wastelands' in the region. In this carefully managed forest, the cuts and clearings left pine trunks in the middle of a living forest. This was a considerable problem because as the trunks rot in the ground, they often became a transmission vector for insects and diseases[33], as well as for fire.[34] Their extraction was therefore strongly encouraged. The difficulty stemmed from pine stumps becoming resinous (and commercially interesting) only after many years in the ground. After this period, however, they were usually hemmed in by a new generation of trees and shrubs, hence their extraction would have destroyed the surrounding vegetation and was out of the question.[35] In writings from the period, it was often pointed out that if pine stumps were extracted immediately after the tree was cut, they could be utilized, if not for wood naval stores at least for manufacturing charcoal.[36] However, even then, their removal was a laborious and expensive task and charcoal manufacture, unlike wood distillation, was hardly an economically viable solution. As a consequence, in the interwar period the transition of pine stumps from waste to a successful raw material, as happened in the US could not occur in France where trunks remained an encumbering and problematic waste for the pine forest owners.[37] Nevertheless, their economic potential loomed large and encouraged discussion on their valorisation in the local economic and scientific press.[38] Pine trunks were, however, rarely objects of interest on their own and much more often they were a part of broader deliberations on forest debris in general.

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[33] Pierre Buffault, "Les Possibilités de la Forêt du S.O.", *Bulletin de l'Institut du Pin* 33 (1932): 193-195.

[34] Louis de Lapasse, "Les Travaux d'Entretien et de Régénération", *Bulletin de l'Institut du Pin* 33 (1932): 196-200.

[35] Georges Dupont, "La Distillation du Bois Résineux", *Bulletin de l'Institut du Pin* 26 (1926): 455-458.

[36] Buffault, "Les Possibilités de la Forêt du S.O."

[37] F. Le Monnier, "Essai d'industrialisation de l'exploitation des bois sur pied à Labouheyre ", *Bulletin de l'Institut du Pin* 31 (1926): 565-570.

[38] The major organ of the local forest workers and the forest workers' syndicates was a weekly published *Bois et Résineux*. A more robust analysis of technology, but also of the state of the industry and of the forest economy were published in *Bulletin de l'Institut du Pin*. It was published by the Pine Institute, the regional scientific and engineering center attached to the University of Bordeaux, but funded through the industry's contributions.

2. Waste or future? Forest fuels in interwar France

A. Forest debris

The Landes forest's soil was covered with pieces of wood, undergrowth, and branches traditionally called *charbonnette* and *menu bois*, either used for the production of charcoal in forest kilns or directly as firewood by the locals.[39] Charcoal was manufactured for domestic use by people living in the region for hundreds of years. However, after World War I it began to be repurposed as wood fuel. France, like many other western nations was interested in securing national fuel sources to become independent of foreign oil importations.[40] It was argued that in the event of a war France would be deprived of petroleum imported from abroad and needed resources on its own territory to ensure the nation's security. In addition, most scientists after WWI believed petroleum deposits would soon be depleted.[41] Consequently, energy security became a major political issue and the French government explored different technological alternatives in a search for the new "National Fuel" (*carburant national*).[42]

Catalyzed by various governmental policies and initiatives, French forest industry leaders lobbied to make wood a "national fuel". Firewood is, of course, one of the oldest fuels used by humans, but its energy efficiency was very low.[43] The place of wood as a fuel changed with technological advances in chemistry and engineering that opened a vast new range of possible uses in the first years of the 20th century. Wood could be either

[39] Louis de Lapasse, "La Production du Charbon de bois dans la Forêt landaise", *Bulletin de l'Institut du Pin* 57 (1929): 71-77.

[40] Michael S. Carolan, "A Sociological Look at Biofuels: Ethanol in the Early Decades of the Twentieth Century and Lessons for Today", *Rural Sociology* 74, no. 1 (2009): 86–112; Helena Ekerholm, "Cultural Meanings of Wood Gas Automobile Fuel in Sweden, 1930-1945", in Nina Möllers and Karin Zachmann (eds.), *Past and present energy societies: How energy connects politics, technologies and cultures*, p. 223-247 (Bielefeld: Transcript Verlag, 2012).

[41] Jovan Milenkovic, *La question du pétrole et des carburants de remplacement en France* (Paris: Edition Pierre Bossuet, 1936), p. 109; *Scientific American* (May 3, 1919): 459 and 474.

[42] Jean François Grevet. "Un carburant « national » pour les transports routiers ou les riches heures du gazogène en France, des années 1920 à l'Occupation," in M.-N. Polino, J. Barzman and H. Joly (eds.), *Transports dans la France en guerre, 1939-1945*, 187-211 (Rouen : Presses Universitaires de Rouen et du Havre, 2007); Joanny Guillard, "Un auxiliaire oublié : les gaz des forêts", *Revue Forestière Française* LIV – 2-2002): 201-203; Camilles Molles, "Rétrospectives sur un « Carburant national » : l'alcool", in Nicolas Stoskopf and Pierre Lamard (eds.), *Transports, territoires et société*, p. 163-171 (Paris: Editions Picard, 2011).

[43] Astrid Kander, Paolo Malanima, and Paul Warde, *Power to the People: Energy in Europe over the Last Five Centuries* (New Jersey: Princeton University Press, 2013): 59.

transformed through saccharification of cellulose into simple sugars and then into ethanol, or be distilled to produce methanol and charcoal, the latter being itself a source of wood gas, which is a mixture of carbon monoxide and hydrogen. The first technology, wood ethanol, had strong support in the early 1920s. Over the period, many countries turned to agricultural crops to produce ethanol: Germany used potatoes[44], while France relied mostly on beetroots.[45] Alcohol was also of interest to the military as it was necessary for gunpowder manufacture. French regulations on the national fuel provided a special legal framework for the use and production of vegetable ethanol, as well as introducing multiple financial incentives aimed at increasing the use of alcohol as fuels. While wood was widely considered as a viable alternative to beetroot in France, wood saccharification technology was not fully developed during this period and failed to gain momentum.

It was the second wood fuel, wood gas used by gasifiers, which stirred the imagination of forest owners with its promises of replacing fossil fuels.[46] Throughout the 1920s, numerous events and initiatives took place aimed at stimulating the manufacture of gasifiers for agricultural tractors, heavy trucks and even for smaller family vehicles. The most spectacular of these events was certainly the French-Belgian competition of gasifier automobiles in 1925, organized by the French Office of Research and Inventions, the Liquid Fuels Office, the Ministry of War, and the automobile clubs of France and Belgium.[47] It was attended by many important French car manufacturers, such as Renault, Panhard et Levassor, Berliet, Schultz et Loriot, and Malbay, and it attracted the attention of both professional and general media outlets.[48]

While the second half of the 1920s appeared very promising for gasifiers, the Great Depression followed by low imported oil prices prevented the technology from gaining more

[44] J. Chevalier, "Le carburant national en Allemagne," *Bois et Résineux* (30 avril 1922); Donald L. Klass, *Biomass for Renewable Energy, Fuels, and Chemicals* (San Diego: Academic Press, 1998), p. 386.
[45] Molles, "Rétrospectives sur un « Carburant national » : l'alcool".
[46] E. Goutal, "Le Carburant National par le Carbone de la Forêt", *Bois et Résineux* (26 April 1925).
[47] Pierre Buffault, "L'utilité nationale du gazogène", *Bulletin de l'Institut du Pin* 56-57 (1934): 141-146, 142.
[48] J. Auclair, "Rapport sur le Concours de Camions à gazogène en 1923", *Recherches et Inventions* (April 15, 1924): 470-403, 471; J. Jagerschmidt, "Le Concours franco-belge de camions à gazogène", *Revue des eaux et forêts* 63 (1925): 509-511; J.-L. Breton, "Résultats du Concours de carbonisation de la Forêt de Senart," *Bois et Résineux* (August 23, 1925); anonyme, "Au concours franco-belge de camions à gazogène", *Le Petit Journal* (September 18, 1925): 3.

widespread approval. This was also due to some problems inherent in the technology itself. Gasifiers were often dirty to handle and needed frequent recharging; they also required a well-developed distribution infrastructure. The forest industry leaders, however persisted and invested in advertising and into research on wood gas, gaining support from some of the most prominent military figures, such as Marshall Philippe Pétain, a war hero and the future leader of the puppet Vichy regime.[49]

Why was the fuel question of such an importance for the forest regions, especially in the Landes? After all, the Landes forest at the time was still primarily a resin factory and its lumber was used in the construction business and in a young paper industry, not to mention that pine trees served as excellent utility poles once treated with preservatives. However, the forest-dependent communities in the region continued to seek out markets for untapped resources from the Landes forest, namely debris and undergrowth. In 1929, forester Louis de Lapasse complained in the pages of a local scientific and industrial review that current charcoal manufacture absorbed but 4 million steres (m^3) of wood, while 12.5 million steres of derelict branches and pieces of wood were strewn on the ground and remained unused in all the French forests.[50] This wasted *charbonnette* could be transformed into 1.3 million tons of charcoal according to de Lapasse. But *charbonnette* involved only larger pieces of wood, while the vocabulary of the French foresters included also *menu bois*, smaller pieces left on the ground after forest clearings.[51] It was estimated that in the Landes forest itself it was possible to gather between 800,000 to 1 million tons of this coarse woody debris and brush (up to 1 ton/ha).[52] The resources of the French woodlands seemed almost inexhaustible and many believed that they were about to revolutionize the economies of the regions relying on timber, giving them a position similar to oil producing regions. Georges Dupont, the director of the Pine Institute research centre in Bordeaux, claimed that the French forests with all their debris could produce enough fuel to effectively replace the entire petroleum consumed in France (even though Dupont's remarks also included lumber

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[49] Philippe Pétain, "Carburant national et véhicules à gazogène", *Revue hebdomadaire* 17 (1936): 391-402, 402.
[50] Lapasse, "La Production du Charbon de bois dans la Forêt landaise".
[51] Charles Colomb, "Les ressources de la forêt française en bois de carbonisation", *Bulletin de l'Institut du Pin* 10 (1930) : 229-230.
[52] Pierre Buffault, "Améliorations à réaliser dans l'Exploitation des Pineraies de Gascogne", *Bulletin de l'Institut du Pin* 55 (1928) : 274-280; Colomb, "Les ressources de la forêt française en bois de carbonisation"

mill waste).[53] It appeared that wood waste could guarantee national energy security and in 1934 the French Ministry of Agriculture created a special commission to work on the use of wood wastes as fuel.[54] Finally, manufacturers of gasifiers fully embraced this rhetoric and companies such as Renault extolled the patriotic and dignified character of forest fuels of national origin.[55]

Locals expressed concern that clearing wood debris would decrease soil quality.[56] However, foresters from the Landes argued that wood wastes were not really necessary for maintaining soil fertility, because pines were supposedly hardy trees that could grow in soils of much poorer quality than deciduous trees. As a consequence, according to prevalent opinion during the period, the Landes forest industry had an advantage over the woodlands where forest debris could not be harvested without prejudicing forest growth. Not only that, both scientists and foresters praised the ecological benefits of clearings, namely fire prevention and protection against insects and tree diseases.[57]

The French national fuel policy made stakeholders 'discover' previously invisible elements of the forest landscape. New economic opportunities sparked scientists, foresters, forest owners and laborers to manage what had been a waste product. Since forest debris and undergrowth were virtually of no economic value, any potential utilization was deemed rewarding and it was expected that these would quickly transition into a fully-fledged raw material.[58] However, using forest waste as a fuel encountered a practical difficulty: cost of harvesting and transportation from the forest to charcoal manufacturing sites. The solution proposed in the middle of the 1920s was to carry out carbonization in the forest itself using small mobile furnaces. Their construction and popularization were strongly supported by the Landes communities and, in 1925, the regional instances organized a competition of these

[53] Georges Dupont, "Le Bois Carburant", *Bulletin de l'Institut du Pin* 13 (1931) : 5-8.
[54] Buffault, "L'utilité nationale du gazogène".
[55] Grevet, "Un carburant « national » pour les transports routiers ou les riches heures du gazogène en France, des années 1920 à l'Occupation".
[56] Roger Pallu, "La Carbonisation dans la Forêt de pins maritimes", *Bois et Résineux* (23 August 1925).
[57] Georges Dupont and M. Soum, "Recherches sur l'utilisation de Quelques Bois Marocains", *Bulletin de l'Institut du Pin* 33 (1927) : 41-44.
[58] Roger Pallu, "L'Alimentation des gazogènes en bois et en charbon de bois", *Bulletin de l'Institut du Pin* 29-30 (1937) : 118-121.

devices.[59] Interestingly, different types of quality benchmarks were proposed. First, all the devices were judged according to how well they transformed *charbonnette* into charcoal. But then they were divided into two categories. The first one consisted of machines adapted specifically for destructive wood distillation of twigs, cones, brush, little branches, and other similar forest debris. The second category of furnace was adapted for sawmill waste, including sawdust, wood chips, and other medium-sized pieces of wood. The former devices were for company forest workers to conduct clearing, and the latter were for use in lumber mills.

[59] Pierre Buffault, "Concours d'appareils portatifs pour carbonisation en Forêt", *Bulletin de l'Institut du Pin* 24 (1926) : 405-409.

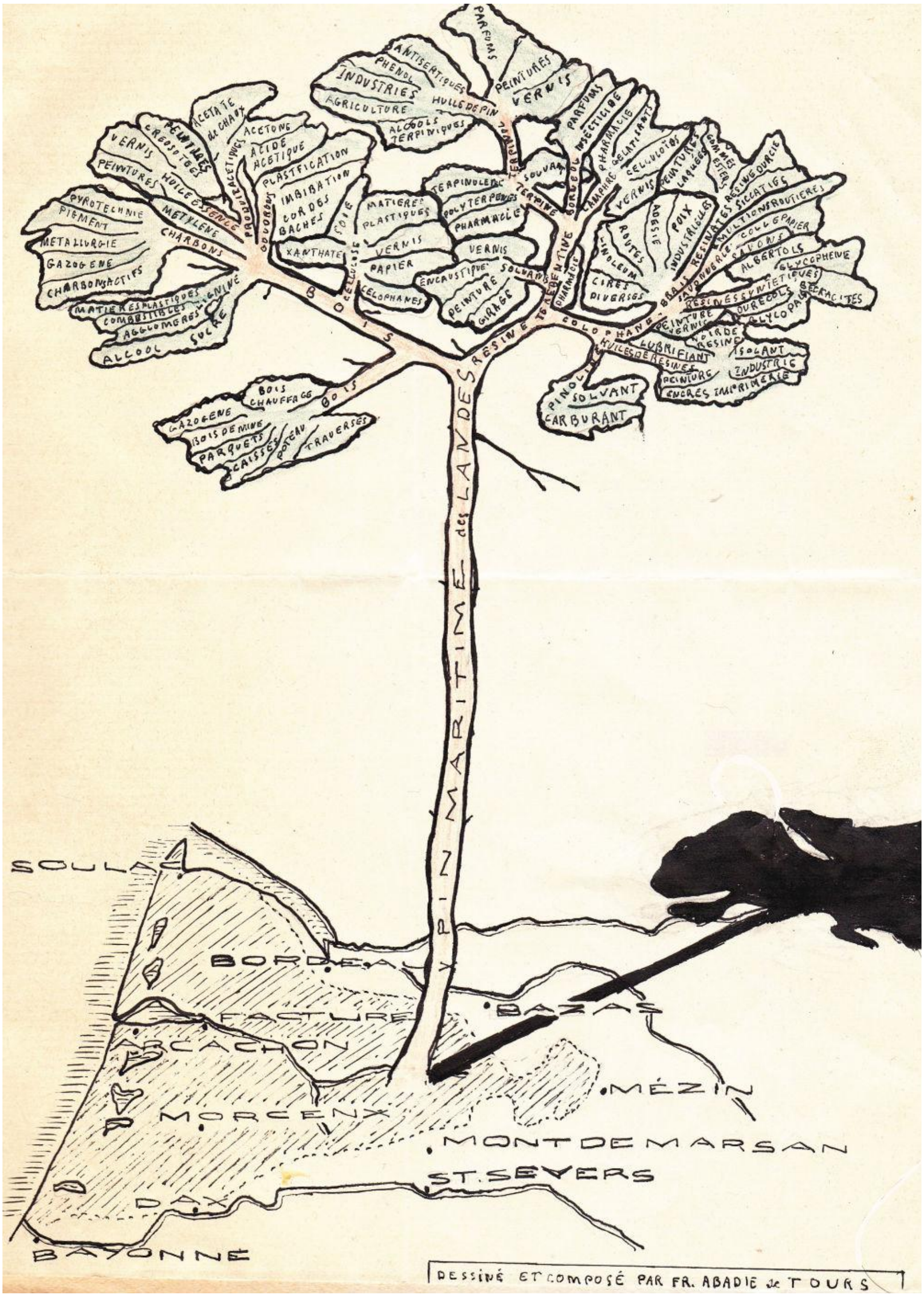

Figure 3: A promotional poster illustrating the diversity of industrial products of pine origin (around 1939). Many of these potential products were to be derived from what was considered a waste.

Source: Pine Institute Archives, Archives Departémentales de la Gironde. No signature.

B. Lumber mill waste

Lumber mills primarily drove expanded use of wood waste as fuel, both in France and in the US. While forest owners had to be convinced of the opportunities offered by gasifiers and wood alcohol in order to put additional effort into harvesting forest debris, lumber mills were businesses that had to dispose of wood waste on a daily basis, which could add to their costs of production. In 1926, Georges Dupont insisted that while forest brush and residue might constitute an interesting additional source of revenue, the true potential laid with sawmill wastes. These were of considerably higher quality than forest debris and would produce not only charcoal for gasifiers, but also a significant portion of methanol and acetone, supplying the national chemical industry.[60]

The experience concerning lumber wastes was very similar on both sides of the Ocean and it readily flowed between France and the United States. For example, an article on wood waste by F.W. Kressman, a former co-worker of the American *Forest Products* journal, was translated into French by two Pine Institute researchers and published in the Institute's own review in 1927. It reported on the potential of timber waste for ethylic alcohol production, in a very similar spirit to the French publications on gasifiers.[61] Kressman remarked that more than half of the tree volume constituted waste: trunk – 2%, tree top – 18%, sawdust – 12%, bark – 10%, tree clipping residue – 16%, wood chips – 4%. This included lumber mill waste and the parts left in the forest after the tree was felled. The author deplored that the quantity of these raw materials currently being used was negligible, especially when the lumber mill was not near a big city. He admitted that transport costs could be prohibitive, but this was precisely why lumber mills should be involved in ethanol manufacture in order to consume wood waste immediately. He argued lumber mills should become distillation centers producing fuels and materials for the chemical industry. Foresters from the Landes insisted on the same thing, but for them it was not ethanol but

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[60] Georges Dupont, "La distillation du bois de pin et ses produits", *Bulletin de l'Institut du Pin* 26 (1926): 455-458.

[61] F. W. Kressmann, "La fabrication de l'alcool éthylique à partir des déchets de Bois", *Bulletin de l'Institut du Pin* 38 (1927): 171-176.

charcoal, tar, methanol, and acetone that should remain at the heart of the lumber mill waste industry.[62]

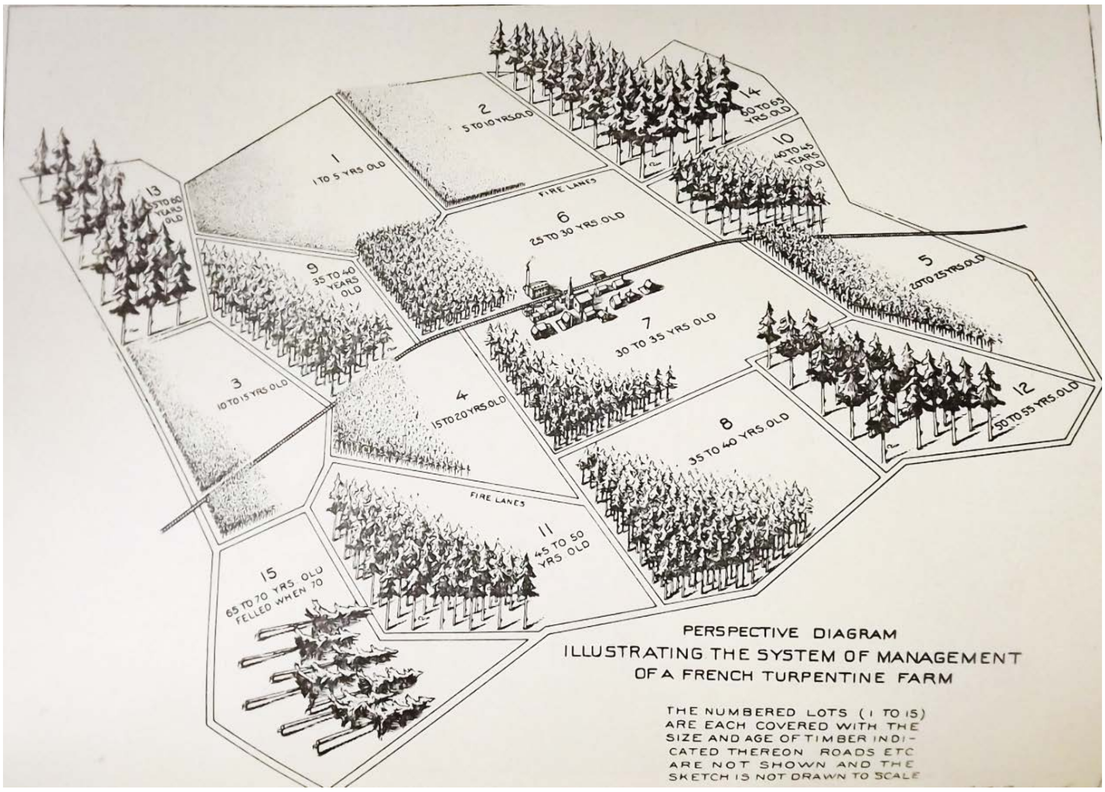

Figure 4: An example of knowledge circulation flow. American rendition of the French pine maritime plantation in a publication of reference from the period.

Source: Anonyme, "The Naval Stores Market of France", in Thomas Gamble (eds.), *Naval Stores: History, Production, Distribution and Consumption*, 163-166 (Savannah: Review Publishing & Printing Company, 1921)

Kressman's calculations regarding the unproductive elements of the tree demonstrate the point explored by Tim Cooper: the sole presence of these unused raw materials that can be qualified as wastes led to discussions on how to profit from them.[63] Once an object becomes a 'waste', it becomes visible to the voracious forces of the market, it produces hopes and promises concerning its commercialization. Of course the question remains how this transition happens; how a passive element of the environment transforms

[62] Pierre Buffault, "La Forêt en Gironde", Bulletin de l'Institut du Pin 7-8 (1935): 129-142.
[63] "Anything, named 'waste' becomes potentially subject to practices of disposal, recuperation and revalorization" in Cooper, 2010: 1120.

into a waste. Interestingly, while the epistemological challenges of the definition of waste are explored in the modern scholarship, the people in the industry in the 1920s were not unaware of at least some of these terminological difficulties. In 1925, F.F. Hawlet, a researcher at the Forest Products Laboratory in Madison, Wisconsin, whose articles regularly appeared on the pages of the French *Pine Institute Bulletin*, remarked that there are two ways of understanding the term 'waste'. On the one hand, waste can be every material of tree origin that is not transformed into wooden planks and similar main products at the lumber mill. But many of these materials can be used to make less profitable forest products.[64] On the other hand, however, there exist also the 'real wastes' that remain encumbering for lumber mills, that have no use and are often burned to dispose of them (the author mentions trunks, but in the post-war period the practice concerned sawdust and similar materials[65]). To put it differently, the term 'waste' in lumber mills denotes either a by-product but with its own secondary market outlets, or a by-product that has no application other than fuel on the industrial site itself. Therefore, any discussion about improvements in the use of forest waste should clearly differentiate between the two. The calculations concerning forest fuel potential of France in the 1920s and 1930s often ignored that much of what was considered waste by lumber mills might have already had a number of smaller market outlets. However, it appears that from our perspective the bipartite division is not enough. What about these elements of the forested landscape that are not even taken into account when the notion of waste is discussed?

3. Optimal use of biomass: scientific narratives on the forest and wood wastes

A. Using the whole tree (cones, needles, bark)

Cones, needles or bark were very rarely debated in the industrial or scientific press in the Landes during the interwar period. We have seen Kressman, an American, noting bark as one of the tree parts that remained unused, but neither he nor his French commentators went deeper into its potential uses. Pine bark was, at best, occasionally mentioned alongside other debris as a material for alcohol or charcoal manufacture. The same concerned pine

[64] Adapted from L.-F. Hawley by M. Soum, "Dix-sept erreurs sur le bois", *Bulletin de l'Institut du Pin* 19 (1925): 289-290.

[65] T. Marshall Hahn, "Wood in Our Energy Future", *Journal of Forest History* 26, no. 3 (1982): 148-153.

cones. These were 'not even wastes', as very few stakeholders in the Landes forest conceived that they might be potentially used on their own. Needles received a bit more attention and in the 1930s, the Pine Institute conducted research at its field station in Pierroton, near an experimental pine forest, on the variation of needle spirit in needles throughout the year.[66] It was suggested that they might find uses in the perfume and soap industry because of their pleasant smell, but this remained a marginal outlet.[67] Needles had a brief moment of glory during World War II when they were used for the manufacture of fibres due to raw material shortages, but again this was an exceptional use. However, in the pine forest, bark and needles were notoriously considered to be a polluting factor as they fell into resin-harvesting cups. They constituted an annoyance that had to be removed because resin distilled with this debris was darker and of considerably lower quality, while the market continuously required purer and purer products. The Pine Institute conducted research on the possibility of using cup lids to prevent pollution, as well as on distilling pieces of wood, bark or even little insects imbued with resin (the so-called *griche*, usually considered a waste) into more valuable products, but with a limited success.[68] Needles, bark, and cones had to wait until the 1970s to become rediscovered by scientists as commercially interesting raw materials.

The 1970s were a turbulent period for the Landes forest. The resin industry, constitutive of the forest's identity for more than a century, almost completely disappeared following the fall of resin prices in France and cheap importations from developing countries.[69] The Pine Institute, funded for years by local resin manufacturing business, had to change its research priorities to wood and natural polymers in order to survive. Luckily for the Institute, saving the forest industry became a priority for the regional authorities. The Pine Institute was at the heart of this shift and benefitted immensely from the funding throughout the 1970s and 1980s to develop new uses for the forest products. On the global

[66] "Rapport sur le fonctionnement et les travaux de l'Institut du Pin en 1932", Bulletin de l'Institut du Pin 40 (1933): 73-77.
[67] J. de Fayard, "L'Essence d'Aiguilles de Pin Maritime", *Bulletin de l'Institut du Pin* 46 (1933): 215.
[68] "Rapport sur le fonctionnement et les travaux de l'Institut du Pin en 1934", *Bulletin de l'Institut du Pin* 3 (1935): 41-45, 42.
[69] Marcin Krasnodębski, "Can Science Feed on a Crisis? Expectations, the Pine Institute and the Decline of the French Resin Industry", *Science in Context*, 30 no. 1 (2017): 61-87.

level, the 1970s were also a moment of transformation in the way of conceptualizing forest resources. In the period following World War II, petroleum reigned supreme and wood was marginalized as an energy source, be it as alcohol or wood gas. This changed drastically during and after the great energy crisis when the concept of biomass gained sudden popularity in the literature. The topic of wood energy returned with full force and forest waste usage was again at the core of heated debates.

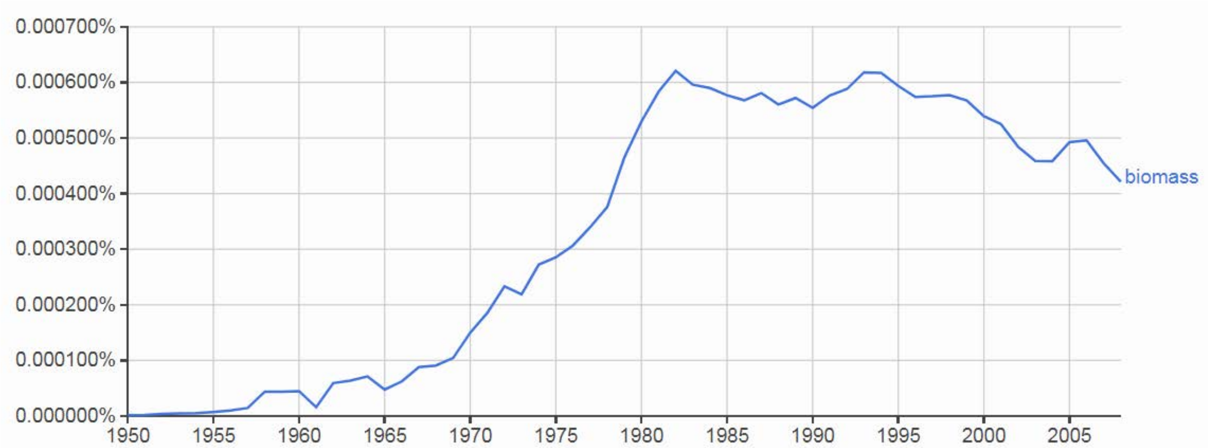

Figure 5: Popularity of the term “biomass” in the English speaking books in the years 1950-2008 (Google Ngram, smoothing=1)

In the middle of the 1970s, the region of Aquitaine, in close collaboration with the Pine Institute, established a development plan for the Landes forest industry enumerating various research priorities.[70] One of its major points was “utilization of the whole tree, including trunks, treetops, bark”. A few years later, in 1977, Jacques Valade, the Pine Institute’s director and the future French Minister of Research and Education, established a working group on forest products reuniting some of the most prominent scientists from public institutions (e.g. CNRS, Pine Institute, and Centre of Paper Techniques) and private companies (e.g. Heurtey and Lambiotte). One of its most discussed topics that led to a few comprehensive reports was “commercialization of organic products from wood and its

[70] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 46 “Plan Décennal – Programme de Recherche. Massif Forestier Aquitaine”

wastes".[71] The working group concerns mirrored the ones from the 1920s and the 1930s, such as efficient charcoal manufacture or wood hydrolysis of alcohol from forest debris. It reflected on the costs of transporting and transforming into energy little branches, brush, bark and similar residues. Once again, the value of wood waste became more widely discussed by the regional press.[72] The working group also explicitly pondered the question of the definition of waste. One of the reports explained that there are four categories of waste sources:

1. Forest (debris, treetops, bark, stems)
2. Industries of the first transformation: lumber mill, wood peeling (sawdust, bark)
3. Industries of the second transformation: carpentry, cabinet making, packaging (sawdust, wood pellets)
4. Industries of paper and panels[73]

Interestingly, the report stated that most of the wastes from the paper industry were already being used, begging the question whether they should be considered wastes at all. The problem concerning the real biomass potential and its supposed promises was remarked on in the US by T. Marshall Hahn, head of Virginia Tech, on the pages of the *Journal of Forest History* in 1982. He explained that wood waste should not be viewed too hastily as a panacea for all energy challenges.[74] He insisted that "there is very little waste in today's commercial forest practices (…). First, the felled tree is bucked into lengths for lumber or plywood. The residues are then chipped for pulp to make paper and paperboard. The planer shavings, plywood trimmings, and fines go to hardboard or particleboard production. The bark is burned for energy. Spent pulping liquors provide energy and a variety of chemicals as well."[75] The Landes forest industry practices were no different. The working group's report came to the conclusion that, before investing in new technologies for commercializing

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[71] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 46 "Economie de Matières Premières « Valorisation des produits organiques issus du bois et de ses déchets », Réunion du 28 septembre 1977, Siège d'Elf-Aquitaine"

[72] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 46 "Plan Grand Sud/Ouest (dossier presse)"

[73] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 46 "Rapport du Groupe « Valorisation des Produits Organiques issus du bois et des déchets » de F. Wable du Groupement européen de la cellulose".

[74] T. Marshall Hahn, "Wood in Our Energy Future", *Journal of Forest History* 26, no. 3 (1982): 148-153.

[75] T. Marshall Hahn, "Wood in Our Energy Future", 150.

waste, it was necessary to conduct a preliminary survey to identify all types of waste, reflect on their current uses, and properly identify the genuinely unexploited elements of biomass.[76]

The idea of exploratory surveys was also strongly advanced by Pine Institute researchers in their own reports.[77] By the end of the 20th century, after taking into account the previously existing secondary smaller outlets for woody debris, the actual definition of wastes 'as forest elements that remain unused' revealed itself to be considerably narrower. In 1992, the Institute enumerated as one of its research priorities "use of biomass: research on molecules from 'forest waste' (needles and bark of maritime pines)".[78] In a trade brochure from the same period, the Institute underlined that it conducted for the industries "analyses of sawdust, barks, pine needles, cones".[79] These previously forgotten materials came to the attention of scientists and companies, seeing them as a new frontier of possibilities.

Research activities on the topic rapidly led to interesting results. For example, scientists showed that pine bark was a valuable source of flavonoids, potentially usable in the pharmaceutical business, as well as phenols which can be used in glues. "[Bark] constitutes effectively a waste, having certainly more remunerable uses than combustion" explained an internal report of the Institute.[80] Needles, on the other hand, were presented as a source of essential oils for perfumes and pharmaceuticals (this possibility had previously been identified by the Pine Institute in the 1930s). But the Pine Institute wanted to focus on a "yet unexplored" acid fraction of pine needle distillate, copalic acids, which are also potentially usable for synthesis of fragrances.[81] Moreover, after the extraction of terpenic

[76] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 46 "Rapport du Groupe « Valorisation des Produits Organiques issus du bois et des déchets » de F. Wable du Groupement européen de la cellulose".
[77] e.g. Pine Institute Archives (Departmental Archives of Gironde): 5908 W 436 "Annexe 3 Recherches relatives au Massif Forestier".
[78] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 35, internal document "L'Institut du Pin : La Recherche… Au service de l'industrie", p. 2.
[79] e.g. Pine Institute Archives (Departmental Archives of Gironde): 5908 W 436 "Annexe 3 Recherches relatives au Massif Forestier".
[80] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 35, internal notice "Institut du Pin : La recherche entre université et industrie", p. 6.
[81] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 35, internal notice "Institut du Pin : La recherche entre université et industrie", p. 5

oils, the remainder of needle mass had no uses other than as fuel or compost. In the 1980s, the Pine Institute insisted that, to manage this waste, new market outlets were necessary and a new treatment technique was proposed that would allow using needles for packaging manufacture.[82] Finally, as for the cones, a Pine Institute internal report deplored that: "When we talk about harvesting the parts of the tree that usually remain abandoned and about using the tree completely, we think about treetops, needles, trunks, bark (…). We always neglect a currently unused lingo-cellulosic material: pine cones left behind after harvesting of the grains".[83] In the late 1980s/early 1990s, the Pine Institute wanted to explore the chemical composition of cones in order to extract residual resin and phenolic substances, and to verify whether cones are fit for papermaking.

In the new logic following the 1970s, biomass was to be used efficiently in its entirety. At first, forest wastes were merely rediscovered as a potential source of energy. But soon, biomass became more and more divided and a rather unspecified mix of debris, once considered a source of fuel, transformed into a set of clearly defined potential forest products. In the 1980s and the 1990s, following the stabilization of oil prices, using biomass as fuel was usually not enough; waste was often precisely what was burned for energy. It was wood chemistry that was supposed to open up new possibilities and make needles, bark or cones genuine raw materials for sophisticated chemical industries so that they would not be 'wastes for burning' anymore. In the same vein, even when scientists discussed the question of transforming forest debris into alcohol or charcoal, these substances were investigated in terms of potential uses for other chemical industries, not necessarily as a fuel (for example, ethanol can be transformed into ethylene which is used for the manufacture of thermoplastic resins).[84]

B. Papermaking and stumps again

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[82] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 50 "Valorisation des aiguilles de pin maritime".

[83] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 50 "Valorisation Chimique des cônes de pins maritimes".

[84] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 46 "Groupement européen de la Cellulose « Note sur la Valorisation des Déchets Agricoles et Forestiers et des Prouits Dérivés de la Fabrication des Pâtes de Bois »".

This shift in the understanding of waste, from raw fuel to a chemical material, also touched the paper industry. In the papermaking process, the paper mills produce tons of lignin, a by-product of the transformation of lignocellulosic materials. The Pine Institute was, of course, called on by the paper mills of the Landes to find new market outlets for lignin since it had no uses other than for heating. Polymers and the glue industry were privileged outlets according to an internal activity report of the Pine Institute from 1989.[85]

Lignin itself is extracted from black liquor, a toxic odorous tar-like substance that is a by-product of the kraft papermaking process. In the first half of the 20th century, black liquor was considered a problematic waste and discharged by paper mills into water, but by the early 20th century its different components found more and more potential uses and black liquor became an energy source on its own.[86] If resinous trees are used for paper pulp manufacture, black liquor contains a significant fraction of tall-oil. Tall-oil is a sticky substance made of resin acids, fatty acids, fatty alcohols, sterols and other alkyl hydrocarbon derivatives that can be distilled to obtain different materials. It can serve, for example, in the manufacture of tall-oil rosins, having very similar composition and properties to rosins obtained in the wood naval stores industry from stumps. The tall-oil industry took off in the US in the second half of the 1950s and completely dominated the rosin market until the end of the 1980s after the pine stump resources expired due to more rational forest management methods.[87] Interestingly, in France, paper mills were much less interested in using tall-oil for rosins. My hypothesis is that it is partly due to tall-oil wood naval stores requiring a special treatment before commercialization if they were to compete with gum naval stores. However, know-how and technical expertise concerning this treatment remained largely unknown in France as a result of the absence of a traditional wood naval stores industry. Consequently, even though the gum harvesting industry declined in France in the 1960s, gum rosins were not replaced by tall-oil ones from the French pines, but by cheap imported resins from Spain, Portugal, and Asia. In contrast, resinous tall-oil had to be got rid of and was often considered a nuisance waste for paper mills in the Landes. Resinic

[85] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 436 "Annexe 3 Recherches relatives au Massif Forestier".
[86] Steven Mufson, "Papermakers Dig Deep in Highway Bill To Hit Gold", *The Washington Post* (March 28, 2009).
[87] Zinkel, *Naval Stores, Production, Chemistry, Utilization*, p. 50.

substances, the basis of the most important industry of the Landes for more than a hundred years, became a waste because of the change in extraction practices.

During the late 20th century, the Pine Institute researchers tried to remedy the situation, extolling the potential of tall-oil uses and were willing to assist paper mills in development of recuperation methods. However, the number of resinous products obtained from black liquor was very limited and paper mills remained unwilling to invest in the technology. The Pine Institute researchers decided to change their strategy and, from the beginning of the 1980s, they conducted research to improve the yield and find new ways of using pines as a resin source in paper mills. They discovered that paraquat, a toxic substance often used as an herbicide, can greatly stimulate resin production by dead pine stumps in the same way various acids were used to accelerate resin extraction from living trees. The exploitation of American stumps was economically viable because, before being subjected to distillation, they had lain in the ground often for decades accumulating resin. With paraquat, French researchers obtained the same concentration of resin in just a few years.[88] French scientists elaborated a technique for recuperating these resinous products by paper mills even before wood was transformed into pulp, therefore considerably improving their quality and quantity as compared to resins from tall oil distillation. Enriched pine stumps were meant to become a new raw material for the paper industry.[89]

It is important to emphasize that in the case of cones, needles and bark and in the case of enriched pine stumps, scientific institutions themselves, not the industry, were a driving force of shifts in the understanding of the notion of waste. Scientific research was not merely in service of lumber or paper mills. After the decline of the resin industry, scientists from Bordeaux attempted, by their own initiative, to redefine their place in the economic landscape and to become a relevant stakeholder again. Acquiring authority and relevance required offering new hopes to the industry. New uses of wood wastes could be unlocked through scientific research. Scientists successfully ‘found’ new types of waste by creating expectations about the potential use of these elements of the forest whose

[88] Pine Institute Archives (Departmental Archives of Gironde): 5908 W 48 “Demande de Crédits Massif Forestier Aquitain – Programme de Recherches de l’Université de Bordeaux I pour l’année 1981”.

[89] Interestingly, in the end the method also failed to convince paper mills, perhaps because of the costs of new installations and continuous flow of cheap Portuguese resins on the French markets.

economic potential had not been considered before. In other words, the concept of wood waste was not only a research object but also a rhetorical tool for constructing scientific authority of the scientists involved.

4. Conclusions

Our reflection led us to construct a brief typology of what can be considered a forest industry waste. Of course, the basic typology may be constructed around the origin of the material: forest, lumber mill or paper mill. But we are first and foremost interested in distinct meanings of the notion of waste itself.

Not even waste (outside the scope of discussions on commercialization)	**Waste (an unused potential)**	**Waste (problematic as it has to be got rid of)**	**So-called waste but in practice widely used**	**Forest products**
- needles, bark, cones until the 1970s (with exceptions) - forest brush, undergrowth, small branches before 'national fuel' policies	- forest brush, branches, and pieces of wood in the forest from the 1920s onwards (after 'national fuel' policies) - bark, needles, cones in the 1980s and 1990s	- rosin in the early 19th century US - pine stumps in the US until the 1920s - tall-oil in France - sawdust	- lumber waste, lignin and other similar materials used in lumber mills, for example as fuel, or having small outlets - acetones and methanol in early carbonization industry	- resin - lumber - pine trunks in the US after the 1920s - plywood - woodchips

Table 1: Typology of pine forest wastes

The first category is 'not even a waste', strictly speaking, as the stakeholders are not aware that it has a potential use. It is a social scientist's category to describe 'waste to be' in some clearly specified circumstances. For example, the post-World War I political climate, led forest debris to 'become' waste as it was realized that components could be used for fuel manufacture. These were not wastes before, but were natural elements of forest landscape with no serious consideration by the forestry industry of their future or potential use. Forest debris advanced in the interwar period to the second analytical category: 'waste as an unused potential'. This encompasses those materials whose economic value is already recognized but they remain unused or underused. The third category, on the other hand, is concerned with by-products that are not only unused but encumbering and required additional investment to be removed. Woodchips in the 1950s and 1960s were such by-products. Some of them were burned for energy but, in principle, most of them were burned in special furnaces just for removal. This was also the case for American rosins in the early 19th century or tall-oil in the French paper mills. This category is particularly prone to shifts as companies are interested in limiting their losses. As for the last category, it comprises by-products of the forest exploitation industry that continue to be called 'wastes' even though they have some market outlets. These are called waste either by force of habit because they remained unutilized at some point of history or because they are simply considerably less valuable than the main product (this was the case for methanol and acetone in the carbonization industry). Of course, the companies may be interested in commercializing the materials belonging to this category by searching for more rewarding market outlets.

The notion of waste is, as we see, a fickle one. While scholars in environmental history correctly understood that modernity produces wastes[90], our research offers a more systematic analysis of factors that contribute to these transformations. The shift from one category to another is due to different 'vectors of change'. Far from giving an exhaustive list, the typology includes vectors of: (1) socio-economic, (2) political or (3) scientific nature. (1) As we have described in the first section, rosin in the US was an encumbering waste while in France it used to be a fully-fledged product on its own. This was because of the difference in the socio-economic context of exploitation: destructive massive-scale deforestation in the US discouraged use of products with narrower profit margins. However, the same conditions that deterred Americans from using rosins for a long time resulted in a pine stumps wasteland that led to the creation of the wood naval stores industry. This could never have emerged in France, where the long-term sustainable exploitation prevented the extracting of resinous stumps. In the US, these became an important raw material; in France, they remained a waste. (2) The second section explained the importance of the political climate

[90] Cooper, 2010.

on shifts in the definition of waste. The political decisions concerning national fuel development in France led to 'discovering' that there was wasted biomass in the French forests that could be potentially exploited, and that forests could become a source of cheap national energy. In a similar way, global political events of the 1970s brought back the question of wastes to public discourse in the context of renewable resources. (3) Finally, in the last section, we saw that scientific research enabled the discovery of new uses for certain categories of products. If we identify a chemical compound of value in a given natural material, it automatically 'becomes' wasted as long as the industry does not find a way of exploiting it. In other words, the extension of knowledge makes us realize lost revenues. But more interestingly, this reflection does not necessarily stem from the industry itself, but from scientists looking for ways to legitimize their position and justify their funding. Scientists create wastes by forging expectations and hopes about the unused economic potential.

We can certainly identify more influences, but the key finding of the paper is that the notion of waste is dynamic and its understanding should not be taken for granted, especially in policy papers. More importantly, we see that multiple transformations of the wastes contribute to the 'flexibilization' of pines as a resource.[91] Pine tree is flexible, thus adaptable to the evolution of the market, precisely because so much of what was considered a wasteful by-product of its exploitation found new uses in different circumstances. But if wastes contribute to flexibilization of a crop, and flexibilization improves its survivability in the market economy, we are led to a somewhat paradoxical conclusion: the generation of wastes in industrial processes can help a given crop to survive. Wastes are unused potential, a promise of untapped riches; any industrial operation where a waste is identifiable hints an opportunity, a 'what if' involving a hope for profit. While green chemistry insists on finding processes that involve no waste generation, it seems that environmental history, sustainability studies, and sociology of expectations, might offer together a fresh and more informed perspective on the actual impact of wastes in designing industrial processes and in

[91] Borras et al., "The rise of flex crops and commodities: implications for research", 2016; Kröger, "The political economy of 'flex trees': a preliminary analysis", 2016.

exploiting natural resources. In other words, these 'waste studies' can hopefully contribute to evidence-based policies for sustainable development.