Port Wine Landscape: Railroads, Phylloxera, and Agricultural Science

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It is easy to understand why regions that produce very fine goods such as port wine tend to conceal technological and scientific inputs and praise the uniqueness of the terroir. This paper suggests that, during the last decades of the nineteenth century, viticulture in the Douro region of Portugal was as much a product of soil, local farming traditions, and individual entrepreneurship as it was of modern state science and national politics for agricultural improvement. The unprecedented public projects of building a railroad and fighting phylloxera permanently changed the land of port wine. Moreover, those engineering practices of rationalization, simplification, and standardization that were inscribed on Douro’s landscape proved essential for the Portuguese experience of modernization and nation-building.

Narratives on the Douro Valley are always worth telling. The uniqueness of the wine produced there and the singular character of the landscape as the river unfolds across northern Portugal draw a worldwide audience. Since the invention of port wine in the seventeenth century, English merchants succeeded in placing it permanently on the table of the most refined European bourgeoisie. As port became an unquestioned cosmopolitan product, it was converted into a national symbol. Portuguese pride in port also reflected its economic significance: during

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the nineteenth century, it accounted for 30 percent of Portuguese exports. Thus, stories about the Douro region and its wine are not peripheral to the nation. They become even more central with the realization that Douro Valley landscapes share, beyond their distinctive features, many historical traits with other territories abroad. Among these is the role of science and technology in crafting landscapes. While historiography has already borne witness to the importance of technology in defining the identity of the United States during the nineteenth century, historians are only now beginning to truly unveil the technological impact in building national cultures in Europe.

On May 4, 1867, the engineer and minister of public works, João Andrade Corvo, addressed the Portuguese parliament on the advantages of building railroads. To brighten his speech he did not refrain from using metaphors: he suggested that the members of the assembly should imagine their country as “a large farm,” a never-ending agricultural dominion. Just as a manager of “an agricultural industry” would invest in soil improvements, irrigation, and the cultivation of new plants, so the state—the administrator of public wealth—had to provide capital for increasing national production. The minister reminded his peers that all money spent on such endeavors would eventually return to the state, and even be multiplied, through taxes. Thus, he emphasized, that all public works expenses had to be understood as productive expenses.¹

Of course this idea of public investment in infrastructure as a catalyst for the economy was not new; it had been presented by many ministers, both before and after Corvo. In fact, the basic principles of political economy that informed it were part of the general doctrine to which Portuguese state engineers had adhered for decades. Therefore, it was not strange that the ministry to which almost all Portuguese technicians belonged, had a composite name, joining “public works,” “commerce,” and “industry” (Ministério das Obras Públicas Comércio e Indústria—MOPCI) in accordance with the Saint-Simonian ideal and creed.²

In spite of their common background, each minister and cabinet member had his own vocabulary and chose his own figures of speech. Corvo, who in 1881 published a small book entitled Political Economy for Everyone, was not mentioning agriculture randomly. Holding a degree in engineering from the Escola do Exército (Army School), this professor of botany at the Escola Politécnica (Polytechnic School) and of rural
economy at the Instituto Agrícola (Agricultural Institute), belonged to a scientific elite for whom Portugal’s prosperity required the exploration and exploitation of its agricultural resources. Like many of his colleagues, Corvo believed that increasing productivity was also a guaranty of national survival; the toil of engineering nature, the work of building a fertile and productive country, was in itself a patriotic mission.

To Corvo’s contemporaries, the railway proved the most complex and difficult communication network to plan and develop. Nevertheless, the politicians hoped to unify, control, and manage the territory through this technology and to foster a nationwide identity through the creation of a unified market. In his opinion “railway building isn’t simply a matter of planning and draftsmanship. It has to be considered from the point of view of economics, and attempt to seek the best doctrines so as not to waste.” Such financial loss could be short term, resulting from bad design or construction, that “costs the state much more” than any such errors in the designing of roads. But there was also long-term loss, even more dramatic and expensive in the end. In fact, political and technical misjudgments regarding the economic viability of a railway line could compromise “the benefits that the railway should bring forth to the country.”

When considering the Douro Valley, however, no late nineteenth-century politician was concerned with viability or relevance. By then, port wine was by far the most productive of all Portuguese industries. The term “industry” was not used arbitrarily. As many researchers have already pointed out, the Douro Valley and its economy constituted the only nineteenth-century example of modern agricultural capitalism in Portugal, involving large amounts and concentration of invested capital and mass proletarianization. According to Corvo, this industry needed public support. With his mind set on the Douro Valley, Corvo stated in the assembly on May 6, 1867: “I consider the railroad not an instrument capable of creating immediate profit but rather a force available to different industries, like a steam engine in a factory serving many different machines.” If agricultural prosperity depended on improved communications, the role of a liberal political government would be to provide them.

However, the Douro railroad did not generate much consensus in the legislative assembly. Despite the region’s economic importance, many ministers could not see the point in planning and building a railroad in a navigable river valley. This attitude suggests how the Douro region
remained, in the nineteenth century, a mystery for the large majority of the population. Just a handful knew that navigating the river was an adventure through narrow gorges with irregular flow rates, only possible for a small group of experienced sailors. Above all, they ignored that, apart from the Douro River, the only communication routes were dangerous mountain tracks, hardly a viable alternative.  

In 1876 the eminent chemist and viticulturist Viscount of Vila Maior, in his popular book *O Douro Ilustrado* (*Douro Illustrated*), contrasted the wine-producing Douro and Rhine regions sharply. While the Rhine, through hydraulic works, was becoming an “industrial river,” nineteenth-century technology proved incapable of taming a river as wild as the Douro. Douro’s wine region did not witness the regular passage of steamboats that could travel along the Rhine, neither did it profit from the commodities and comforts of northern Europe’s “most demanding civilization.” Above all, it was not a main thoroughfare, capable of responding to the new and exigent necessities of a market economy. The one hundred twenty kilometers connecting the heart of the Douro region, near Pinhão, with Oporto’s harbor and the Atlantic Ocean, demanded at least two days of travel, and sometimes, when traveling upstream, more than a week. A railroad could predictably follow the same route in just a little more than four hours, with a greater assurance of safety to the passengers and cargo. Additionally, transportation fees would be considerably reduced. By train, the cost of carrying the forty to fifty thousand wine barrels that on average went downriver each year would be reduced by more than half.  

However, the railroad did not offer only economic benefit. Portugal, said Corvo in the 1860s, “has to consider its obligations as a civilized country.” This implied that modernizing transportation in the Douro Valley, doing away with the need for human and animal power as much as possible, represented also an improvement of the nation’s standing. Of course, the concept of civilization was much broader by the end of the century. By then, a civilized state needed to control all its territory. It was impossible to govern the unknown; thus, the so-called “politics of legibility”—cartographic surveys, statistics, and the standardization of measures adopted in Portugal and in many parts of the world—underpinned this political worldview. For central authorities in Lisbon during most of the nineteenth century, the Douro region existed exclusively in
the customs’ balance sheet, in the form of taxes placed on port wine. The arrival of the railroad, however, made a geographic region, once invisible due to its inaccessibility, recognizable and controllable. It helped organize a part of the natural world and integrate the landscape of the Douro Valley in the rest of the nation.7

On July 2, 1867 Corvo signed the law that authorized the state to plan and build the Douro railroad, merging the government’s economic and colonizing goals. The government considered the line a true service to the nation. So, the central administration in an unprecedented move, decided to fully take charge of all execution phases of planning, building, and administering the infrastructure. Previously, all Portuguese railroads had been awarded to private consortia and joint ventures.8

Francisco Sousa Brandão, an engineer trained in the Parisian École des Ponts et Chaussées, drafted the first design for the Douro railroad. In the mid-1860s he was the nation’s premier railroad engineer. His expertise was not just the result of his good French technical education. Although Portuguese engineers had never built a railroad without foreign help, they had managed to create a solid corpus of knowledge regarding the coordination and evaluation of public works. Brandão—as a member of the bureaucratic elite educated to build the nation state—had been involved in the strategic planning and inspection of Portuguese railroads since the 1850s. His expertise also reflected Portuguese reforms of the mid-nineteenth century. Around the end of the 1830s, the government had created new technical schools, and, in 1852 the MOPCI established bureaucratic procedures to regulate the management of public works.9

Regardless of legislation, some engineers thought the Douro railroad was impossible to build. Brandão demonstrated that the line was feasible. In his initial reports, he proposed that the railway be built parallel to the right bank of the river, from Oporto to Pinhão. In fact, the final version, took a detour from the river in the first fifty kilometers. In spite of being longer, this route offered important economic counterbalances, since it crossed a fertile valley, allowing a faster and more regular supply of fresh produce to Oporto. However, the harsh topography of this diversion brought added difficulties to the project. It entailed the construction of the largest tunnels, bridges, and viaducts of the entire railway. Consequently, technology had to master nature on a greater scale than expected, which challenged the project’s budget.10
This modification to the original plan had enormous implications, both in the short and long term. “It is a well-known truth, an infallible rule, that the less you spend on the construction of the railway, the more you will spend on its maintenance,” declared Brandão in the assembly. In fact, railroad engineers always had to juggle two opposing realities: cheap construction favored smaller curve radii and steeper grades, while future profit necessitated wider curves and gradual slopes. The mastery of railroad design depended on successfully merging these conflicting demands. The Douro railway was no exception.  

Mapping the route was only the start of building a railroad. Contrary to road building, railroads also required an understanding of mechanics and metallurgy. This knowledge had to inform the plan, which was not only a technical tool, but also the subject of a rigorous bureaucratic procedure. Engineers of the MOPCI had established “regulations for technical and economic management and evaluation” and a set of “forms, types, and models” for all projects. These administrative instruments defined an orderly sequence of steps and stipulated types of drawings, technical specifications, and supplies needed for calculating the budget. This standardization allowed senior engineers from the MOPCI to efficiently evaluate each design and execution phase. All the regulations demanded that the engineers dedicate special attention to cost estimates, which were of particular interest to politicians.  

However, the engineers’ work did not end with an approved plan. They also had to oversee construction, which was of utmost importance. Negotiating with workers, managing contracts for the supply of materials, directing subcontractors, and meeting the landowners to be expropriated, were all part of the state engineers’ daily routine.  

In fact, even when working with a good project, building was never linear. Engineers had to think simultaneously about the availability of labor and materials, the suitability of particular months for particular enterprises, and railroad priorities. Two letters from the director of construction, Lourenço António de Carvalho, deal specifically with management problems. Construction of the one-and-a-half-kilometer tunnel close to the small village of Juncal presented a case in point. There, as in other Douro tunnels, the lack of geological and hydrographic surveys made building slow and unpredictable. After evaluating “the characteristics of the terrain at certain points, the abundance of water and the need for
reinforcing the tunnel surface,” Carvalho decided to center the contracting work there to prevent time slipping away. He also focused his attention on the main bridges. Even though iron construction had less open variables than tunneling, the vast majority of the pillars were made of stone, making them hard to carry and slow to mount. Thus, this part of the project needed to be started before the metallic part of the bridges was fully designed. Beside tunnels and bridges, the main construction task was earthworks. Ultimately, the railroad was a hymn to human labor and animal strength. More than 65 percent of the 3.9 million cubic meters of earthworks was transported using shovels, wheelbarrows, or oxen carriages. The other 35 percent rolled over rails, but initially even the railroad carriages depended on the energy of horses. In a region where the entire labor force came from abroad and was seasonally concentrated, finding workers was a difficult task.  

In June 1875 the first section of the railroad was finally opened. The newspaper *Comércio do Porto* (*Oporto Trade*) described the “enthusiastic party” of military parades, music plays, flags, flowers, fireworks, and speeches in detail. Each subsequent opening saw the same events, and, in each case, the engineers were celebrated as major heroes. This small group of young Portuguese engineers allowed the government to claim the nation’s technological autonomy, conveniently obscuring that the funding was to be largely raised abroad, and the technology imported. The team also proved to be decisive in construction of a professional identity.  

No one could have predicted that, by the time railway was completed along the Douro, a strange disease would be threatening the entire port wine industry, which the train was built to serve. But in fact, railroads and modern pests were not strangers. In a revolutionary system that ran according to the standardized time of clocks, the rhythms of human work, and ultimately of nature, were subjected to a profound transformation. The increasing pace of agricultural production—caused, in part, by railroads—mobilized the entire agricultural scientific community. In agricultural institutes and experiment stations in Portugal and abroad, scientists tested new crops and breeding methods to better respond to a growing market. Again, the state had a central role. In 1852 the MOPCI founded the Agricultural Institute to educate a new generation of Portuguese agricultural scientists. In April 1876, recognizing the economic and
political importance of scientific agriculture, parliament issued a law creating a professional position for an agronomist in all the seventeen districts of Portugal. These experts were sent to colonize the country.\textsuperscript{15} 

The collection and development of resistant and productive botanical species became an important part of these scientists’ work. To accomplish this, they promoted the interchange of plants between the New and the Old World, including grapevines. American species, stronger and more productive, proved of great interest to European producers. During the nineteenth century, growers from France, Portugal, Spain, Italy, and Germany imported many American varieties. On the other hand, in the United States, viticulturists widely planted European stocks because of their high quality musts. Most European vines died. American producers, erroneously, blamed the soil and the climate. In fact, as European researchers discovered, the European vines could not resist a specific native American pest. With steamships and railroads significantly reducing the length of time of transatlantic journeys, American plants entered Europe with living plagues and parasites. Thus, the desired universal communication led to the introduction of \textit{phylloxera vastatrix} in Europe, and Douro’s agriculture suddenly faced a major scientific problem.\textsuperscript{16}

The arrival of phylloxera, combined with the economic and symbolic importance of port wine, provoked a direct intervention by the Portuguese state. During the late 1860s producers realized that a strange disease was affecting Douro’s vines. According to their descriptions, vines weakened and dried, without any noticeable or identifiable cause. \textit{Oidium}—the fungus that ravaged European vineyards in the 1850s—was not to blame. In fact, the new disease had completely different manifestations. To address its unknown etiology and rapid spread throughout the Douro’s wine region, the first official inquiry commission was sent to the valley in 1872. Many others followed. Their members were the most influential chemists, agronomists, biologists, and entomologists of nineteenth-century Portugal. From the first, and by governmental order, the main national research institutions—University of Coimbra, Agricultural Institute, Polytechnic Institute, and Lisbon Science Academy—sent their scientists to the Douro. The sole objective was to save port wine production.\textsuperscript{17}

Solving the problem of phylloxera took time. Jules Planchon, the first European scientist to see the insect on the roots of vines, identified it as
the cause of the disease in 1868. His conclusions, however, did not achieve scientific consensus. For many European researchers it seemed unlikely that such a small insect could cause such huge destruction. Motivated by the German chemist Justus Liebig’s well-published 1840s discoveries on plant nutrition, they argued that the disease resulted from major soil degradation. In the Douro region, farmed for centuries without adding any fertilizers, the theory seemed absolutely plausible. The collection of more trustworthy data, continent-wide, was necessary to solve the problem. Wine production was important enough to motivate states’ bureaucracies. European governments supported a network of international researchers, with France’s viticulture schools at the center. Researchers paid by public funds finally proclaimed that, indeed, the destruction was caused by this small insect.18

Even before finding an effective solution to phylloxera, scientists had to try to staunch its progression through Europe. In 1878 in Berne, representatives from France, Portugal, Spain, Italy, Germany, Austria, Switzerland, and Hungary gathered in an International Congress to define basic control measures. International cooperation was essential, as phylloxera, ignoring all political frontiers, had attained epidemic proportions. The countries consensually approved a draconian law. To save the market economy it was necessary, paradoxically, to stop its main motor: the circulation of commodities. Only by using customs to control international plant transport and by limiting exchanges within each country, could the disease’s progression be blocked. Along with these basic measures, it was urgent to evaluate the scale of the infection. In this regard, congress scientists and politicians decided that each country should support surveying commissions to observe and track the insect in specific localities and also try new treatments. Creating such groups first entailed training people to see the small aphid that insidiously attacked the vine’s roots. The second step was establishing an organized and hierarchical system, as coordinated administration was crucial in the fight against phylloxera.19

Regional action mirrored these international decisions. The Viscount of Vila Maior was appointed by the government in August 1878 as the president of the commission for the study and treatment of the Douro vineyards, while, entomologist Manuel Paulino de Oliveira, professor in Coimbra, wrote the first report. He clearly stated the importance of the
surveying commissions. Paulino chose prominent producers and landowners as heads of local commissions. They were entrusted with identifying infected vines, tracking the progression of the disease, and ensuring regular treatments. Paulino also wrote an illustrated manual in which he described phylloxera biology, identified vine symptoms, and instructed commission members in their particular tasks. Engaging landowners with public policies, surveying, and other tasks was essential. Only by gaining the support and recognition of producers was it possible for scientists to closely observe and treat the vines. Despite the involvement of locals, more people were required, mostly to help smaller-scale viticulturists. Each municipality created the position of “phylloxera expert” to find and treat the bug. These lay practitioners joined more formally trained experts to apply treatments against the disease.20

Commissioners, experts, and practitioners gradually transformed the Douro Valley. Landscapes were now captured through the cartography that tracked the progression of the insect. Phylloxera, having already created a scientific network, now produced a new vineyard, where surveying and treatment became normal procedures.

To stop the plague, the anti-phylloxera commission engaged in a chemical war. Among other solutions, carbon disulfide was the most applied insecticide. Resulting from a combination of carbon and sulfa at high temperatures, this compound is a highly volatile, inflammable, and toxic liquid with insecticidal properties. Literally injected into the soil, it killed the pest by asphyxia. However, to apply carbon disulfide with uniform success, many years of field trials were needed, as no scientist could assure that the amounts they applied successfully in Languedoc or Bordeaux would have similar consequences in Douro. Broad-based conclusions on the response of phylloxera to carbon disulfide could only be validated by studies that considered local variables. At a time when laboratories were the sole source of modern science and controlled experiments the sole mode of validating scientific knowledge, agronomists recreated Douro vineyards as a laboratory space. In the infected lands of Quinta do Porto, Quinta da Plombeira, and a group of smaller estates near Régua, occupying almost twenty hectares scattered throughout the Douro, agronomists adjusted their field research practices to the basic principles of laboratory work. However, in opposition to the controlled reality inside laboratory walls, the natural state of an infected vineyard offered too many
variables—type and age of vines, phase of the disease, chemical composition of the soil, topography, and solar exposure. To these variables, agronomists added other elements like the amount and characteristics of fertilizers and carbon disulfide. To cope with this complexity, vineyards were divided into experimental plots, each receiving a combination of treatments. For each field station, agronomists published annual reports and analytic tables, summarizing the results of tests and observations.\(^{21}\)

The results of such experiments fundamentally reconceptualized perceptions of landscape. The data collected in the Douro state farms made it possible to determine, with considerable level of precision, the quantity of insecticide to be applied per hectare, according to the types of soil and humidity. Agronomists also established the best space intervals between injections. This acquired knowledge was translated into conceptual graphics defining an abstract topography of circles and crosses (see Figure 1), an ideal landscape dreamt for the Douro Valley.

**Figure 1.** The Vineyard as a Laboratory.

Application system of carbon disulfide: crosses represent the vines and circles the place to inject insecticide.

Field trials in experimental stations and the work developed on other vineyards led agronomists to the conclusion that phylloxera was not the only problem. Indeed, “the vine culture was threatened by myriad concerns.” According to agronomists, the main problem they faced when testing pest treatments was the uneven distribution of vines in the fields. The geometric disorder, consequence of ancestral planting methods, did not facilitate the treatment and the use of mechanical devices. Ordered vines allowing precise recordkeeping was the main precondition for scientific agriculture. In the new planted plots in the field stations, this had been created with much success. Only by expanding the field station type of organization—by implementing a scientifically intensive production of lined-up and trimmed vines, occupying fertile land—could the future of Douro vine production be assured.

As the space of vintners started to be scientifically colonized, the landscape changed dramatically. When replanting, steep hillsides and less productive lands were abandoned. Gradually, small, narrow terraces gave way to wider, more regular ones. These larger spaces accommodated the

**Figure 2.** Scientific Landscape.

Biel’s photograph of a grape harvest at Quinta do Noval.

planting of up to ten parallel rows of vines, instead of just a single row. This spatial reconfiguration allowed viticulturists to double the density of their vineyards: from three thousand to almost six thousand plants per hectare. Thus, the old tortuous vineyards were transformed into a landscape of uniformity. In the words of the actors, this careful planning was necessary for “plentiful and speedy production” in a “rewarding” way. Despite its focus on efficiency and economy, the new order managed to create a geography of unexpected aesthetic fascination. And this fascination, inherently modern in nature, endured; by the 1940s these nineteenth-century terraces, with “their impeccable alignments,” still impressed Álvaro Moreira da Fonseca, one of the leading agronomists of the time.23

Although restructuring the landscape was important to industrial production, soil fumigations to kill phylloxera were key. These applications, which perfectly embodied the principles of the new scientific agriculture, built a durable connection between railroad and pest. In France, nineteenth-century railroad companies’ estimates of the volume of carbon disulfide to be transported were so high, that such companies decided to support research defending chemical treatment as the best answer for vine problems. This lucrative alliance between transportation companies and science also occurred in Portugal. First, the Portuguese state assumed control and direction of all the research done, and second, it centralized the responsibility for treatment. During the 1880s the state-owned Douro railroad carried, free of charge, some eight thousand tons of carbon disulfide from Oporto to the wine country, corresponding to almost forty thousand hectares of treated vineyards.24

State intervention was not limited to transportation. All the carbon disulfide used in Portugal from 1880 onward was manufactured in a state-owned plant built exclusively for such a purpose in Oporto. This permitted increased production and allowed landowners to buy insecticide at cost, avoiding the price-gouging inherent in those always-scarce French products. Soon it became clear that the introduction of carbon disulfide was dependent on the large-scale use of fertilizers, as the insecticide sterilized the soil. The Portuguese responded accordingly. From 1880 the Douro railroad transported, gratis, all fertilizer used in the war against phylloxera. Storage was equally important. Station warehouses and depots dotted the new scientific Douro geography. Their modest
appearance concealed their importance and effects on the landscape. Concentrating treatment materials and products, they were circulation centers for modern agricultural practices throughout the whole region.\textsuperscript{25}

From the middle of the 1880s it was clear that the use of American vines as rootstocks was the best solution for phylloxera. The subsequent prolonged use of carbon disulfide can only be ascribed to motivations beyond those of scientific reasoning. National pride proved an important factor. As Paulino said: “in the regions where there are already a considerable number of plants infected, we must make an effort to preserve \textit{our varieties of grapes}, destroying phylloxera and increasing vine resistance” (italics added). Indeed, preserving local varieties was a priority to all the major European wine-producing countries. This was only possible by using carbon disulfide and fertilizers. Far from being a definitive solution, it allowed phylloxera to become a chronic problem. Producers believed that the use of American vines corrupted the purity of indigenous varieties and ultimately worsened wine quality. They also thought that consumers’ sophisticated palates, long accustomed to a particular taste, would not endure the difference. In the end, wines from Champagne, Burgundy, the German Rhine, and Douro, were much more than commercial products. They were seen as the liquid translation of those countries’ souls.\textsuperscript{26}

Just like port wine, the new uniform and geometrically ordered landscape became a national symbol. Terroir gained a visible shape by the end of the century. Engineers and agronomists were not alone in this civilizing and colonizing mission. Photographers, also acting as men of science, created a modern, public image of the Douro landscape. They made hundreds of incursions into the territory and chose vantage points and specific angles to compose their visual records. Their pictures, which in the nineteenth century were seen as epitomes of objectivity, truthfulness, and precision, more than documenting the new reality, contributed to a common understanding of its meanings. Many photographs were taken to glorify those who transformed the land, but many more were made to celebrate the landscape itself. Thus, modes of production and modes of representation are two halves of a single story. Douro landscape-building coincided with the development of modern photographic techniques in Portugal.\textsuperscript{27}

Emílio Biel was the main Douro photographer of the nineteenth century, and his albums established the concept of Douro as a technological
landscape. Biel depicted almost all aspects of Douro’s wine-making process: vintner houses, wineries, warehouses, workers, riverboats, barrels, bottles, and, of course, the landscape of railroad and vines. Not a single fragment of Douro escaped his gaze. These were all registered on glass plates and printed on durable photographic paper. Such pictures illustrated popular books, but mostly circulated in the form of postcards—a quintessential product of nineteenth-century commodification and one of the most lucrative businesses of Biel’s photographic industry—reaching a national audience. Better than written narratives, photographs helped to construct a popular appreciation of such engineered landscapes. For the Portuguese elite, the photographs that Biel shot in the Douro Valley in the late 1870s functioned as a strategic mirror for the technological identity and political legitimacy of the nation.28

NOTES


3. For the construction of national territory through infrastructures, see, for example, Marc Desportes and Antoine Picon, De l’espace au territoire: L’aménagement en France, XVIe–XXe siècles (Paris: Presses de l’École Nationale des Ponts et Chaussées, 1997), 67–107; Diário da Câmara ano de 1867, 1400–1401.


10. Ibid., 193–229.

11. Diário da Câmara ano de 1867, 1427.


17. José Duarte de Oliveira Junior, António Batalha Reis, Jaime Batalha Reis, A nova moléstia das vinhas no Douro: relatório apresentado à comissão central (Lisboa: Imprensa Nacional, 1873); Providências legislativas adoptadas em Portugal contra a phyloxera vastatrix desde 1876 a Março de 1883 (Lisboa: Tipografia da Casa Minerva, 1883).


21. Paul, Science, Vine. On the importance of field science, see, Robert E. Kohler, Landscapes and Labscapes: Exploring the Lab-Field Border in Biology (Chicago: University of


