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The Emergence of Forest Genetics in Portugal: The Works of Joaquim Vieira Natividade (1899–1968) in the Alcobaça Cork Oak Station

ABSTRACT

This paper aims to contribute to a better understanding of the history of biology and forestry in Portugal. It will focus on the one state-owned cork oak station devoted to forestry research, showing how its foresters and scientists shaped, and relied on, the state-controlled unions, both for producing and distributing varieties of cork oak and for controlling the seeds and plants forest owners used. Portugal played a very special role in the international development of Mediterranean forest genetics during the first half of the twentieth century. Forestry genetics were decisive for the Estado Novo government, and the Alcobaça Station became a model for the future organization of other countries' applied forestry research centers. The paper shows how the milieu of forestry scientists and breeders played an important role in the development and institutionalization of genetics in Portugal. The paper will explore how these relationships made it possible for the scientists to test, multiply, and distribute the seeds and plants they produced at the laboratory throughout the Portuguese landscape, thus demonstrating the role of scientists as active agents of state formation and landscape transformation within a corporate political economy. The history of the Alcobaça Forest Station is an important example of fascist institution building.

KEY WORDS: forestry, cork, fascism, history of genetics, plant breeding, experimental system

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The following abbreviations are used: EAN, Estação Agronómica nacional; *HSNS*, *Historical Studies in the Natural Sciences*; ISA, Instituto Superior de Agronomia; JBS, Jorge Brito dos Santos; *JHB*, *Journal of the History of Biology*; JNC, Junta Nacional da Cortiça; MGG, Manuel Gomes Guerreiro; NFS, National Forest Service.

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For twenty years, a strong connection between state and cork oak trees emerged in Portugal, in which cork oaks were considered a priority target for state intervention because they were seen as the easiest path toward transforming forestry practices to meet pressing needs for a better export supply. Modernizing the cork oak industry became a political project that materialized under António de Oliviera Salazar's fascist regime and contributed in turn to shape and legitimize the Estado Novo as a "planner state." The constitution of the genetically homogeneous cultivar as a scientific object, a market commodity, and a state policy object went hand in hand. This turned Portuguese cork oak stands into an enormous laboratory. Salazar's forest technocrats envisioned Portuguese forest landscapes as a space in which improved genetic assemblages would be rationally and efficiently distributed. Although the state was not the sole actor of the cork sector, engineers made it into a key player.

Much of the early history of forest genetics in Portugal and Spain remains to be written. Forestry experts who were engaged in cork oak breeding placed themselves at the center of a vertically integrated system that attempted to unify state politics, capital, labor, and scientific research. How did forestry scientists participate in the regime rather than come to work under it or despite its official policies and rhetoric? How did modern genetics reach Portuguese forests through the Alcobaça Cork Oak Station during the decades of 1930s and 1940s? As Michael Flitner has demonstrated, mid-twentieth-century "genetic modernizations" targeted plant, animal, and human populations and deeply intertwined eugenic, agricultural, and geopolitical dimensions, although they did so in differing ways across national contexts.[1] The forestry scientists who appear in this paper employed their knowledge in relation to the immediate needs of the state. Political economy not only imposes constraints upon science, but also presents motivations and resources for scientists and their research.

Since the Cold War the public imagination has tended to consider freedom and democracy as key drivers of technological progress. Historians have spoken of engineers as working under Estado Novo and focused on the significance of censorship over science and technology. In Spain and Portugal the common association of science to democracy have led many of them to argue that the

1. Michael Flitner, "Genetic Geographies: A Historical Comparison of Agrarian Modernization and Eugenic Thought in Germany, the Soviet Union, and the United States," *Geoforum*, 34 (2003): 175–186; Helen Anne Curry, "Radiation and Restoration; or, How Best to Make a Blight-Resistant Chestnut Tree," *Environmental History*, 19 (April 2014): 217–238.

political situation virtually erased research;[2] others have argued that this science was pseudoscientific. Still others have argued the engineers' successes were accomplished in spite of the regime. This kind of perspective was partly based in Cold War Mertonian narratives.[3] Scholars now approach the question of technical research by asking what topics the politicians favored and what kinds of international links they depended on. To what extent were forest science and technology a part of diplomatic arrangements in Salazar's Portugal? This is not meant to minimize the tragic effects of repression and ideology on science under the new regime. It does take seriously, however, the emphasis the regime placed on "applied science," which gives us an insight into the actual interconnectedness of research and the Portuguese Estado Novo political economy.

Any analysis of the relative vigor and quality of genetics research in Portugal must take into account the institutional environment, or what Charles Rosenberg has called the "ecology" of the discipline. In Rosenberg's view, the swift rise to prominence of the American school of genetics was made possible by certain important institutional developments.[4] One derived from the rapid enlargement after the 1890s of opportunities for research and graduate training in American universities.[5] On the other hand, I will use the notion of "labscape" to suggest the extent to which laboratory work is involved in producing and maintaining those landscapes. Robert Kohler has used the concept of labscape to explore the laboratory-field border in the natural sciences. Labscapes are thus those landscapes one cannot fully understand without mentioning laboratories.[6]

This paper will focus closely on the actual development of concrete technical products as a way of illuminating the role of engineers in shaping the-political economy. This attention allow historians to consider concrete physical transformations happening outside laboratories as part of the history

2. María Jesús Santesmases, "Severo Ochoa and the Biomedical Sciences in Spain under Franco, 1959–1975", *Isis*, 91 (2000): 706–734.

3. Lino Camprubí, *Engineers and the Making of the Francoist Regime* (Cambridge, MA: The MIT Press, 2014).

4. Charles E. Rosenberg, "The Social Environment of Scientific Innovation: Factors in the Development of Genetics in the United States," in *No Other Gods*, Baltimore: Johns Hopkins University Press (1976): 196–209, 197.

5. Daniel J. Kevles, "Genetics in the United States and Great Britain, 1890–1930: A Review with Speculations," *Isis*, 71, 258 (1980): 441–455, 451.

6. Robert E. Kohler, *Landscapes and Labscapes: Exploring the Lab–Field Border in Biology*. Chicago: University of Chicago Press (2002); Tiago Saraiva, "Fascist Labscapes: Geneticists, Wheat, and the Landscapes of Fascism in Italy and Portugal," *HSNS* 40, no. 4 (2010): 457–498.

of science and technology. Only a few exploratory studies have looked into the interface between genetics and agriculture or forestry in Spain and Portugal,[7] and historians have not systematically examined Vieira Natividade's ideas and life. Some of these studies have started to challenge the Mendel-centered view of plant breeding, and have instead documented much more complex, locally situated, reciprocal relationships between academic studies of heredity and breeding activity. But the deployment of genetics among forestry scientists and breeders remains underestimated.

What really changed in the experimental practices of these researchers, and to what extent did private and public cork oak plant breeders apply or develop Mendelian strategies? This is where the notion of "experimental systems" can be useful. Hans-Jörg Rheinberger has provided a theoretically elaborated definition.[8] He regards experimental systems as the smallest integral working units of research that are designed to create new phenomena and knowledge. Theoretically, he discerns in them two types of elements. He calls the first a scientific object, or an "epistemic thing." An epistemic thing is "that material entity which is the object of manipulation." During the research process scientific objects continually make their appearance and become successively redefined in changing experimental contexts. These contexts form the second element of the experimental systems, and Rheinberger calls them technical conditions, or "technical things."[9] They are materials and methods of experiments that "determine the space and realm of representation of an epistemic thing." In case history studies, experimental systems typically consist of heterogeneous elements, such as groups of researchers and their networks,

7. Susana Pinar, "The Emergence of Modern Genetics in Spain and the Effects of the Spanish Civil War (1936–1939) on Its Development," *JHB* 35, no. 1, (2002): 111–148; Júlia Gaspar, Maria do Mar Gago, and Ana Simões, "Scientific Life under the Portuguese Dictatorial Regime (1929–1954): The Communities of Geneticists and Physicists", *Host: Journal of History of Science and Technology* 3 (2009); Maria do Mar Gago, "The Emergence of Genetics in Portugal: J. A. Serra at the Crossroads of Politics and Biological Communities (1936–1952)" (Master thesis, Universidade de Lisboa, 2009); Lino Camprubi, "One Grain, One Nation: Rice Genetics and the Corporate State in Early Francoist Spain (1939–1952)," *HSHS* 40, no. 4 (2010): 499–531; Marta Macedo, "Império de cacau: Ciência agrícola e regimes de trabalho em São Tomé no início do século XX," in *O império colonial em questão: Poderes, saberes e instituições*, org. Miguel Bandeira Jerónio (Lisboa: Edições 70, 2012): 289–316.

8. Hans-Jörg Rheinberger, "Ephestia: The Experimental Design of Alfred Kühn's Physiological Developmental Genetics," *JHB* 33 (2000): 535–576.

9. Hans-Jörg Rheinberger, *Towards a History of Epistemic Things: Synthetizing Proteins in the Testube* (Stanford, CA: Stanford Univerity Press, 1997), 28–31.

aggregates of equipment, techniques and methods, research materials, concepts and assumptions.[10]

Attention to concrete objects could shed light on circulation of theories and methods as well as on spatial and temporal continuities. The category of objects finally calls attention to the plant varieties foresters and forest owners dealt with. Starting their careers in the context of a forest station, cork oaks successively became objects of experimental inquiry, first by forest scientists and then by progressive farmers. With their transfer from academia to the forest, plant varieties turned into scientific objects. They became "epistemic things"; that is, they became part of experimental systems,[11] generated questions, initiated research processes, and asked for new or refined concepts and theories. In the process of working cork oaks, their shapes had been transformed, and their behavior had been altered. By 1960, they were the product of thirty years of human intervention and control. It was possible to ask, "Are these trees technology?"[12]

The first section of this article shows how the milieu of forestry scientists and breeders played a much more important role in the development and institutionalization of genetics in Portugal than has previously been recognized. The second section accounts for the limited importance breeders' gave to Mendelism by using Hans-Jörg Rheinberger's notions of "experimental system" and "epistemic thing." Following the scientific life of the leading Portuguese geneticist and forester Joaquim Vieira Natividade (from 1930 until 1960), I analyze the emergence of genetics in the Portuguese Forest Service. Here I add a further dimension by examining the relation between science and politics as a reciprocal one. Our narrative ends in the 1950s when the relationships between Vieira Natividade and the Forest Service changed noticeably.

THE SCIENTIFIC AGENDA OF THE PORTUGUESE REGIME: RESEARCH AND INSTITUTION BUILDING

After sixteen years of a Republican regime, a military coup took place in 1926 and put an end to a situation that had been deteriorating in social and

10. Christophe Bonneuil, "Mendelism, Plant Breeding and Experimental Cultures: Agriculture and the Development of Genetics in France," *JHB* 39 (2006): 281–308, 281.

11. Thomas Wieland, "Scientific Theory and Agricultural Practice: Plant Breeding in Germany from the Late 19th to the Early 20th Century," *JHB* 39, no. 2 (2006): 309–343.

12. Susan Schrepfer and Philip Scranton, *Industrializing Organisms: Introducing Evolutionary History* (New York: Rutledge, 2004), 261.

economic terms. A military dictatorship emerged and led to the recruitment of António Salazar (1889–1970) as Finance Minister in 1928. In 1933, an authoritarian regime was installed in Portugal with the name of New State—Estado Novo in Portuguese—and with Salazar as its leader. This kind of fascist-oriented country opposed nineteenth-century laissez-faire ideologies and so explicitly made autarchy an important goal. This required colonizing new lands or increasing production in agriculture, energy, and industrial goods. This fully fledged regime founded on a corporate constitution in 1933 would last till 1974. It replaced any form of liberal mechanisms of representation by ideological nationalism, the one-party state, systematic repression, and a social and economic corporatism formed by alleged organic social unities—a combination that placed it among the family of European fascist regimes.

At the same time, between 1918 and 1936, the cork sector in Portugal was going through difficult times. Cork oak (*Quercus suber L.*) is the native tree with the highest economic value to Portugal.[13] In 1939, more than one-half of the world's supply of cork was coming from Portugal.[14] This tree is the only source for industrial cork, a raw material in high demand for the production of wine bottle stoppers and as an insulating material in construction. For instance, the 1929 economic crisis had an important impact on cork exports. The United States, which had been purchasing 60 percent of total Portuguese cork exports,[15] drastically reduced its demand. However, even when cork production often stagnated during the 1920s, cork extraction remained high. In fact, cork demand was so high that people began indiscriminate cork harvesting to the point of extracting too much "virgin cork" from the trees. At the time the emergence of these bad practices led to attempts by interested parties to enforce administrative measures for the protection of cork oaks.

It can be observed, therefore, that public efforts, though cautious, were made to ameliorate the situation in the Portuguese cork sector. These efforts were coordinated actions among cork stakeholders, but in general, neither the

13. Maria Carolina Varela and Gosta Eriksson, "Multipurpose Genetic Conservation in Quercus Suber—a Portuguese Example," *Silvae Genetica* 44, no. 1 (1995): 28–37, 28; Luis Gil, "Environmental, Sustainability and Ecological Aspects of Cork Products for Building," *Ciência & Tecnologia dos Materiais* 23 (2011): 87–90.

14. Amelia Branco and Francisco Manuel Parejo, "Incentives or Obstacles? The Institutional Aspects of the Cork Business in the Iberian Peninsula (1930–1975)," *Revista de Historia Económica—Journal of Iberian and Latin American Economic History* 1 (2008): 17–44.

15. António Mendes de Almeida, "O Sobreiro Português," *Boletim do Ministério da Agricultura*, Ano XIII, no. 1, 1.a Serie, (Setembro 1931).

monarchy (before 1911) nor the republican government (until 1926), coupled their rhetoric with strong political action in the cork economy. In 1924, the National Forest Service (NFS) took the decision to create research laboratories in two small towns, Marinha Grande and Alcobaça, granting researchers means, albeit limited, to conduct research and training. The first to be installed was the Resin Laboratory (1924). The first director was Francisco Santos Hall, who remained the principal fellow for six years. Dedicated to *Pinus pinaster* research, Hall studied the resin extraction method "establishing the principal experimental basis."[16] Hall had received training abroad, in Germany and the United States.

In the 1920s, one of the directors of the NFS was the forester Antonio Mendes de Almeida. Under Mendes de Almeida, the NFS started to create a strong culture of research among state foresters; the "conservators" started to work with "laboratory scientists." The environment of Portugal, like Spain, Algeria, or Southern Africa, suffers from a relative paucity of trees as a result of Mediterranean climate evolution.[17] Mendes de Almeida was one of the first to try exotic trees in the drylands of the south of Portugal; he was impressed by their ability to grow quickly where other trees could not, such as the genus *Eucalyptus*. Another important genus with which Mendes de Almeida engaged was *Acacia*, or wattle.[18] At a practical level, no importance was placed upon the distinction between native and exotic. He considered that the success of plantations would be a result of years of testing and experimentation, that would lead to better species selection and the creation of hybrids that prospered in Mediterranean climates.

Thanks to Mendes de Almeida, some rules for cork stripping were made for the first time; the increasing demand for cork as an export product in addition to supplying the local market placed pressure on these forest resources. But Mendes de Almeida was conscious that without a better understanding of the biology of the tree, new laws could have negative effects on forest conditions. Mendes de Almeida emphasized decentralized research; in 1930, the Cork Oak

16. Ignacio García-Pereda and Ana Cardoso de Matos, "The Portuguese Forestry Community and Research Fellows Abroad Between 1915 and 1946," *Delfim Santos Studies*, no. 1 (2012): 160–175.

17. Robert Hickel, "El problema de la repoblación en la cuenca mediterránea: Proyecto de creación de una Asociación Forestal Mediterránea," *Revista Montes* 827 (1911); Diana K. Davis, *Resurrecting the Granary of Rome: Environmental History and French Colonial Expansion in North Africa* (Athens, OH: Ohio University Press, 2007).

18. António Mendes de Almeida, "Arborização do Algarve," *Agros, Boletim da Associação dos Estudantes do ISA,* 1° ano (1917).

Station was finally installed at Alcobaça, near the Vimeiro National Forest. This second center, like the first in Marinha Grande, was directed by an outstanding forester trained abroad: Vieira Natividade. The Alcobaça laboratory was the first-ever explicitly designated "forest genetics" laboratory on the Iberian Peninsula. The laboratory developed cytological research, a domain that had remained underdeveloped in Portugal and Spain forest plant biology between the wars. The Alcobaça laboratory would be the ideal place to "enable biologists to study natural objects—organisms—on experimenters' terms, not nature's, free of all the messy complications of life as it is actually lived in a crowded and changeable world in which everything is related to everything else."[19]

In Portugal, other research laboratories and stations for genetics research also emerged during the Estado Novo. The laboratory for genetics and seed selection was founded in 1937 in the Estação Agronómica Nacional (EAN) by António Câmara.[20] Câmara, holder of the chair of agriculture at the Lisbon Institute of Agronomy (Instituto Superior de Agronomia, ISA) and a friend of Vieira Natividade, was chosen as the head of the EAN instead of Mário de Azevedo Gomes, a former agriculture minister and head of the Lisbon Agriculture Station (Estação Agrária Central) between 1923 and 1935.[21] Câmara embodied a technocratic model of state intervention over agricultural production and distribution, which corresponded to the state-controlled style of the Salazar period. He had received training abroad, at the Plant Breeding Institute in Cambridge and at the Kaiser Wilhelm Institut for Breeding Research in Berlin. His stay in Germany was critical to his notion of the role of scientific institutions. Câmara was struck by the connections between genetics research and the political economy of fascism, the common worship of political leaders Hitler and Salazar.[22] The reflection was celebratory, not critical, but in some occasions he would use German war rhetoric to explain that "research is not a Blitzkrieg wherein any offensive success can be verified."[23]

19. Kohler, *Landscapes and Labscapes* (ref. 6), 473.

20. Domingo Victória Pires, "As bodas de prata da Estação Agronómica," *Revista Agricultura* (Dezembro 1961).

21. Ignacio García-Pereda, *Mário de Azevedo Gomes (1885–1965): Mestre da silvicultura portuguesa* (Sintra: Parques de Sintra, 2011), 52.

22. Saraiva, "Fascist Labscapes" (ref. 6); António Câmara, "As Investigações Genéticas no Kaiser Wilhelm Institut: O Ambiente de trabalho em Dahlem," *Revista Agronómica* 25 (1937): 56–71.

23. António Câmara, *No Caminho, Guiando uma empresa científica* (Leiria, Portugal: Tipografia Alcobacense, 1943), 177.

Other geneticists also played a key role in the newly emerging Portuguese biopolitics: José Antunes Serra and Domingos Rosado Victoria Pires. Serra had been one of the first Portuguese public breeders to develop Mendelian research with the help of the EAN and the National Board of Husbandry.[24] Victoria Pires, founder of the Elvas Breeding Station, in 1934 had a scholarship at the Svalöv Station, in Sweden.[25] He was the agriculture secretary of state between 1950 and 1958. Figures such as Câmara, Victoria Pires, and Vieira Natividade, scientific plant breeders, praised the revolutionary role of science in agriculture and forestry, and the revolutionary role of Mendel's laws of inheritance in plant breeding, and spent a considerable amount of experimental effort to align breeding concepts and practices with genetic concepts and practices. When the EAN was established in 1937 as a powerful agency for agricultural research, it was plant breeders, rather than other groups with stronger academic links to the ISA, or disciplines as economics, who were chosen to head it.

But the scientific agenda of the Portuguese fascist regime cannot be reduced to the foundation of laboratories exclusively dedicated to applied science. A less obvious interface between the state and the scientific elite emerged from the 1933 Constitution. Indeed, this Constitution not only served to legitimize the political regime imposed in May 1926, but to reorganize Portugal into a "corporative" state. Be it rice, wine, cod, or fuel, every major product or raw material deserved a new, rational para-State corporate institution that controlled imports and export, wages and quality. In 1936, Salazar took the opportunity provided by the civil war, which started in Spain between fascists and supporters of the Popular Front's government, to strengthen the country's social structure with organizations of a fascist character, such as the National Cork Board (Junta Nacional da Cortiça, JNC).

Institutions such as the JNC are at the heart of the debate about Portuguese corporatism as an authoritarian political experience. The corporate organization of the State relied on several new institutions, among them the so-called institutions of economic coordination (*organismos de coordenação económica*). These institutions were created because Salazar did not believe the Portuguese society to be ready for corporations. Even if he could trust the "capital-work relationship" to be supervised by primary corporate institutions (such as syndicates or employers' guilds), he could not do the same with the economy of

24. Gago, "The Emergence of Genetics" (ref. 7).

25. Domingo Victória Pires, *O melhoramento de plantas em Svalov* (Lisboa: Casa Portuguesa, 1935).

the country. The system would restructure the political economy into a centralized hierarchy, making sure that every level of each branch of production was coordinated to serve the national interest. Authorities took over control of the cork production; this did not require nationalizing the economy, but integrated its different agents into a structure controlled by the state. This implied not the fixing of prices, but the control of intermediaries from the forest to exporters

> the care lavished in Portugal on the preparation of corkwood for the market is known all over the world. Long practice in handling the raw material has created a class of skilled operatives in this trade. The JNC guides and inspects the whole trade and sees that official regulations are observed.[26]

The JNC, able to control the good quality of the national cork, became the state's agent for these tasks and was placed into a complex network of commissions of boards. The Salazar laws embodied the visions of the development of the economy on a nationalist basis under the direction of the State. Such combination, typical for many state policies of the Depression years, would materialize the presence of the New State in the territory.

New laws forced all Portuguese forest owners and cork industries to join their respective regional union, in turn affiliated with the JNC. Foresters specializing in tree genetics certified the quality of raw material sold by others and produced their own seeds and distributed them through the Forestry Service. This made them key actors in tree standardization and homogenization. These engineers were able to use the vertical structure of the regime to demand more responsibilities. Every level of each branch of production should be coordinated to support the national interest. This poses the question: to what extent was cork part of a promotional program and a project to assert state authority? The role of techno-scientific elites was crucial for the regular activities of these state organisms. A paradigmatic example is discussed in this paper: the collaboration, from 1936 onward, between the JNC and the Alcobaça Station.

26. Joaquim Vieira Natividade, *Portugal, the Greatest Cork-Oroducing Country in the World* (Porto: JNC, 1939), 9. Some of the main "institutions of economic coordination" were the National Federation of Wheat Producers (1933), the National Board of Fruits (1936), the National Board of Wine (1937), and the National Board of Olive Oil (1937).

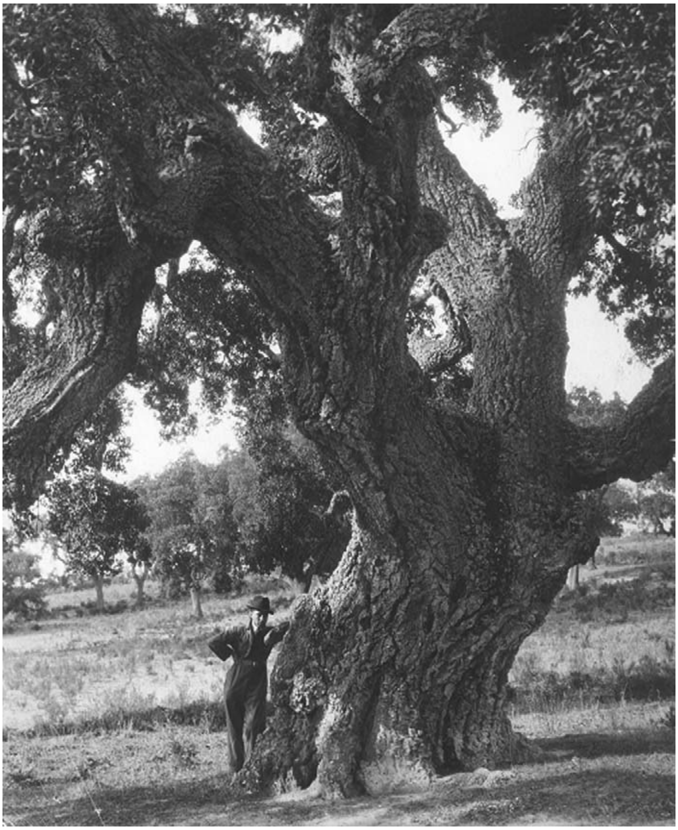


FIGURE 1. Joaquim Vieira Natividade, JNC photo collection, Instituto Conservaçao Natureza e Forestas Archives.

VIEIRA NATIVIDADE: SHAPING A GROUP OF FOREST GENETICISTS

Vieira Natividade graduated as a forester in 1929 (Fig. 1). In 1930, he was appointed head of the Alcobaça Station and put in charge of organizing its laboratories and experimental fields. With the creation of the JNC in 1936, he obtained an important position within the planned political economy: being one of the four members of the Board, representing the NFS and all forestry production.[27] From that moment on he was the main link between forestry

27. Ignacio García-Pereda, 2008, *Joaquim Vieira Natividade (1899–1968): Ciência e Política do Sobreiro e da Cortiça* (Lisboa: Euronatura, 2008), 76.

and the system of vertical unions through the JNC. Vieira Natividade was able to take advantage of state intervention to foster both his administrative career and his research on cork oak genetics. Moreover, he could use his knowledge as a forester to actually shape and organize this state intervention.

Clearly, Vieira Natividade, like other genetic researchers and scientists such as Câmara, was not simply mobilized by the state or working under its dictatorial political pressure. Rather, both took the opportunity afforded by the new regime to give a new relevance to their work and orchestrate support for it through their own administrative positions. In 1933, work on cork oak genetics began at the Alcobaça Station in the context of a plant breeding plan. But the first years at the Alcobaça Station were fraught with poor working conditions. In 1931, there was not even a respectable microscope, and Vieira Natividade had to bring with him the know-how and curiosity for laboratory life.

This movement toward forestry genetics, the first in the Iberian Peninsula, was certainly related to the scientific activity of Vieira Natividade. In the Lisbon ISA, he had met professor Joaquim Rasteiro. Rasteiro was one of the first to teach breeding in the agronomy curriculum.[28] He and like-minded professors viewed breeding as an activity that could easily incorporated into the industrial setting, using mechanical equipment and under the direction of engineers.[29] In the ISA in 1929, Vieira Natividade finished his forestry studies, a diploma opening the possibility to join the NFS.[30]

In 1931, Vieira Natividade financed himself a fellowship to spend some weeks in London visiting Cyril Dean Darlington (1903–1981), head of the John Innes Institute, to learn about cytological techniques.[31] The John Innes

28. Mário de Azevedo Gomes, "Estudo biográfico sobre o engenheiro agrónomo Joaquim Pedro d'Assunção Rasteiro," *Anais do Instituto Superior de Agronomia* VI, Fasc. 10 (1934).

29. Helen Anne Curry, "Industrial Evolution Mechanical and Biological Innovation at the General Electric Research Laboratory," *Technology and Culture* 54, no. 4 (2013): 746–781, 749.

30. In 1916, the Portuguese NFS employed ten foresters and more than 300 forest guards.

31. "I've received a great deal of studying material, thanks to your kindness and to some American institutes. It's well known that Mr Crane and Mr Darlington have improved the above subject and finding in the course of my work some difficulties in regard to cytological techniques, please answer the following questions: Could you consent me assisting to your laboratory works during a fortnight? It's the utmost time I can stay at England. Would Mr Crane be kind enough in helping me to resolve some problems of cytological techniques that's interests me most particularly? . . . A I'm the chief Forest Engineer of the Experimental Stations of Sobreiro, I'd apply to you laboratory in an official study commission although the expenses are due to me, I'd be provided by credentials of the Agriculture Department. . . . I am well acquainted with French, Spanish and Italian. Although I may translate correctly the English language, I've great difficulty in speaking it. In these conditions do you think me enable of understanding Mr Crane?" Vieira

Institute was one of the only places in Europe carrying out research on heredity and genetics. Darlington was discovering, in those years, the centrality of chromosomes to heredity, variation, and evolution. The British scientist saw that the chromosomes were not only the products of evolution, but also its guides; their structure and properties determined its course as much as the changes taking place at the gene level.[32]

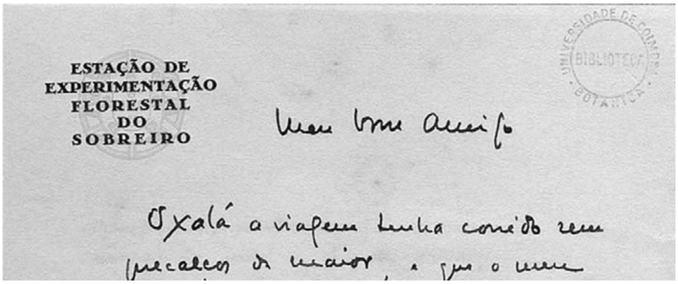
We have to remember that Vieira Natividade had finished his forestry studies after studying agronomy (1922). Alcobaça was an important point for pomology (the branch of botany that studies and cultivates fruit) in Portugal, and the engineer's first books in the 1920s were mostly related to apple production. In London, Vieira Natividade was able to improve important techniques useful for his genetic work. At the John Innes Institute, researchers were working on cytology, genetics, botany, and pomology. After that trip Vieira Natividade began to look at chromosomes, whose mysterious movements and structures he found more fascinating than anything anyone else was working on. Observing the chromosomes, Vieira Natividade followed every move, learning their likes and dislikes. He studied in considerable detail the size relationships of the cork oak chromosomes,[33] showing the somatic chromosome number ($2n = 24$). With a sharp eye and distrustful mind he tamed the chromosomes, imposing order where others had seen only disorder.

Returning to Portugal, Vieira Natividade decided to continue his training in genetics. Early in his attempts to develop plant breeding methods, Vieira Natividade gained the cooperation of biologists and agronomists in neighboring regions and in Lisbon. He started visiting other experimental stations, such as the Botany Institute of the University of Coimbra. Together with Aurelio Quintanilha (1892–1987), Vieira Natividade was able to work in better facilities than those of the Alcobaça Station. Vieira Natividade found in Quintanilha (one of the first biologists in Portugal to publish on genetics) a paragon reflecting his own developing sensibilities and a testament to the viability of iconoclasm and rugged individualism. Sitting side by side in the laboratory, both men spent many hours discussing genetics and politics, combining ideas.

Natividade letter to the John Innes director (Daniel Hall), 29 Jul 1933, Vieira Natividade files, Alcobaça Public Library.

32. Harman Orem Solomon, "Method as a Function of 'Disciplinary Landscape': C. D. Darlington and Cytology, Genetics and Evolution, 1932–1950," *JHB* 39 (2006): 165–197, 192.

33. Joaquim Vieira Natividade, "Investigaçoes citologicas nalgumas espécies e hibridos do género Quercus," *Publicaçoes DGSFA*, 4 (1937): 68.



ESTAÇÃO DE
EXPERIMENTAÇÃO
FLORESTAL
DO
SOBREIRO

Meu bom amigo

Oxalá a viagem tenha corrido sem
percalços de maior, e que o meu

FIGURE 2. Letter, Vieira Natividade to Quintanilha, October 1934, Coimbra Botany Institute Arquives.

Quintanilha, for his part, began to fancy the shy and intelligent youth, recognizing his scientific acuity and encouraging him (Fig. 2).[34]

A first work about pomology breeding would be presented to the ISA professors, in the context of an exam in 1933 to occupy Rasteiro's position, who had died some months before.[35] With the help of Quintanilha, better conditions for the emergence of genetics at Alcobaça Station were being created. The technical and theoretical background on genetics acquired by Quintanilha in Germany was added to Vieira Natividade's experimental skills in biology, learned from the London circle of geneticists. The choice of candidate was based on personal connections rather than test results; Vieira Natividade could not take the Lisbon position and decided to stay in Alcobaça "forever." It was a fact in 1933 that university position was given according not to scientific merit but to ideological affinities, and the Agronomy Institute was viewed more as place of instruction, rather than research. Vieira Natividade returned to his birth city, now with the idea (and at that time, the only professional option as civil servant) to bring genetics techniques to the cork oak experiments, after having made the first attempts with the pomology tests. Vieira Natividade felt he had been let down by the University: "Here [in Alcobaça] I spend all my time working and studying, increasingly isolated, and increasingly removed from the hustle and bustle of life. I stay with the study of cork and cork-oak. It's sad, but it's life!"[36]

34. Aurélio Quintanilha, "Prof. Eng. Joaquim Vieira Natividade: O investigador, o agronomo-silvicultor, o homem," *Boletim da Sociedade Broteriana* 43 (1969): 7–23, 8.

35. Joaquim Vieira Natividade, *A improdutividade em Pomologia, Estudo Fisiológico e Citológico* (Alcobaça: Author, 1932).

36. Vieira Natividade letter to the agronomist Salustino da Graça do Espirito Santon (from São Tomé), 29 Jul 1933, Vieira Natividade files, Alcobaça Public Library.

But it would not be easy; cork oaks are characterized by very high allogamy, immense genetic variability, late flowering and slow development. In 1934, Vieira Natividade received the first of his collaborators in Alcobaça: the forester Domingos Pereira Machado. The new Institute combined routine testing with pure and applied research, and soon became a magnet for forest science. With the arrival of Machado at Alcobaça, Vieira Natividade began to function as a mentor, awakening some Portuguese foresters to the new science of heredity. Until 1950, Vieira Natividade was able to control a coherent agenda at the research school. The number of forest engineers in plant genetics and plant breeding in Alcobaça increased from two in 1934 to seven in the 1940s; all of them used breeding books, revealing the influence of science in that detailed record keeping is a standard procedure of experimentation. A community of academic forest breeders had come into being. Vieira Natividade's group of forestry science disciples was formed between those years, each approaching science in a different way. One of them was Manuel Gomes Guerreiro (1919–2000), who stayed in Alcobaça until 1954. Guerreiro is remembered as one of closest of Vieira Natividade's disciples because he received laboratorial training in experimental biology in the Alcobaça laboratory and was then awakened to the problem of heredity, writing his forestry thesis about the *Populus* genus of trees.[37]

Another good example of the collaborators was Jorge Brito dos Santos, who stayed in Alcobaça between 1938 and 1946. In the 1940s, he was invited by the National Cork Board to run a project of cork oak improvement and technical forestry assistance. This collaboration lasted almost three decades; in 1967, he was named President of the Board. Vieira Natividade, Guerreiro, and Brito dos Santos' contribution to the Alcobaça Station and to the Board was mainly to scientifically supervise the design of cork oak breeding experiments, which took place in the Vimeiro forest and aimed at the reduction of cork defects through proper selective methodology. Like the EAN, the Alcobaça Station was built specifically for Vieira Natividade to conduct research on cork oak breeding and genetics. And like the National Board of Husbandry with Serra, the JNC opted to support Vieira Natividade's research, a situation which avoided, at least for fourteen years, important difficulties in terms of material organization and scientific practices. At the same time, Vieira Natividade's

37. Manuel Gomes Guerreiro, "Sobre o problema do melhoramento florestal do genero populus. A experimentação cientifica e a técnica florestal," *Publicações DGSFA*, Vol. XI (1943). However, he opted for a career professor opportunity in the ISA, with the same bad result as his mentor, and finally decided to go to Mozambique to work in a new Colonial Research Station.

team took advantage of the publications of the Board to disseminate original theoretical ideas about cork oak breeding.

Just as scholarships allowed Portuguese foresters to visit some experimental stations abroad, the Estado Novo government provided scholarships to allow some outstanding international scientists to visit Portugal. In May 1935, the British agronomist John Russell (1872–1965), head of the Rothamsted Station, spent two weeks traveling all around Portugal.[38] An official letter from Celestino da Costa, President of the Education Board, was necessary. Russell arrived in the port of Lisbon on the 21st, and one of the first professors he met was António Câmara,

> a very attractive young geneticist who has worked with Crew for some time at Edinburgh and also been to the John Innes Institute where he got to know Darlington. He speaks English perfectly. He is now studying *Drosophila* and also the chromosomes of wheat . . . he knows Vaviloz and has had discussions with him . . . Câmara explained to me the wheat campaign . . . he is responsible for the field experiments and later on suggested that he and Rothamsted should collaborate, if possible, on joint field work . . . Câmara is one of the professors who has private means of his own and is therefore able to devote himself full time to his work . . . professors have to seek another occupation and so can give only part of their time to the College.

On the 26th of May, Russell visited Marinha Grande and Alcobaça, and spent some hours with Vieira Natividade and his wife, Irene. In his notes the Englishman would remember the good taste of the young couple, and how "after seeing the Station we went round to his house to tea beginning with Port wine and strawberries, and on to tea and delicious cakes." Alcobaça was starting to be a scientific destination on the European map.

Two other international forestry scientists who visited Vieira Natividade came from France, Henri Gaussen and Jean-Pierre Chesneau.[39] Chesneau published the report of the visit in the *French Forestry Review*. In his text he considers the conditions of the Portuguese forest administration as "excellent," where all the forest rangers' houses had toilet and bath. At Alcobaça, Vieira Natividade showed the Station to the Frenchman, who would recall the authority and respect of Vieira Natividade inside the Forest Administration,

38. Rotahmsted Station Archives, Collection Russel, Portugal Travel Box. Câmara never worked directly with forest trees issues.

39. Henri Gaussen, "Le Milieu physique et la forêt au Portugal," *Révue Géographique des Pyrénées du Sud-Ouest* XI, no. 3 (1940): 219–267.

where he was seen principally as "technical cork advisor." Chesneau regretted not having the time to translate the beautiful publications of the Station, where it was "possible to feel the perfection of the cork oak culture in Portugal."[40] Alcobaça researchers under Vieira Natividade's direction took pains to distinguish their work from that of private forest owners by identifying themselves as men of science. Most of the books and articles related to cork published in Spain and Portugal between 1936 and 1950 were written by the Station's staff. In particular, almost everything related to forestry genetics published in both countries during that period was produced by these researchers.[41] Rather than being civil servants with only marginal technical knowledge, it was the scientific status of the Alcobaça's forestry scientists generally, and of Vieira Natividade in particular, that allowed them to become active agents within the state's structure.

In 1950, as a sort of scientific legacy coinciding with his resignation as the head of the Cork Oak Station, Vieira Natividade published a special book, *Subericultura*.[42] This 312-page edition included, after a survey of the relevant literature, a history of general cork oak genetic work. Finally, it provided a detailed account of the activities performed at Alcobaça in relation to cork oak improvement. The text established the political economy of cork production and consumption in botanical and genetic research.

BETTER CORK FOR THE NATION: SELECTION OF THE PLUS CORK OAKS AND THE ALCOBAÇA'S EXPERIMENTAL SYSTEM

Vieira Natividade was one of the strongest advocates in the Iberian Peninsula for scientific plant breeding in the 1930s and 1940s. In a time of increasing industrial demand, Vieira Natividade saw that there were problems of producing high-quality cork. Pest and disease as well as mismanagement were among the factors; two others related to the principal lines of the genetics work of the Station from the very beginning. The first was breeding: cork oak improvement through the formation of new hybrids, using the method of induced mutability. The chromosomes of numerous forms of cork oak were studied at Alcobaça, including the heredity of the principal characters of the plants. Vieira Natividade collaborated with collectors who sent him plant material from all

40. Jean-Pierre Chesneau, "Le chêne-liège au Portugal," *Révue des Eaux et Forêts* (Août 1947).

41. Fernando Molina Rodríguez, "O melhoramento genético da floresta na Espanha," *Pinhal e Resina* 5 (1949): 41–47.

42. Joaquim Vieira Natividade, *Subericultura* (Lisboa: Ministério da Economia, 1950).

around the country. But the slowness of these operations was described as "despairing."[43] Conventional breeding of cork oak is constrained by its long reproductive cycle, which includes long juvenile periods, and by its complex reproductive characteristics, including self-incompatibility and a high degree of heterozygosis. It's not surprising that the genetics of forest trees came under study then; the assumptions are brought into better focus when they are considered in relation to other twentieth-century forestry aspirations. That one benefit of this genetics research should be its contribution to speed and efficiency in forestry production reflected broader trends in the rural economy. In forestry these ideas found audience in extension agents and government officials alike, who became increasingly concerned with mechanizing and industrializing forestry to bring it in line with the ideals of modern production.

The second line of genetic work was the study of the processes of artificial multiplication. The vegetative propagation techniques permitted the establishment of clones from the selection of the best individuals. But vegetative propagation was not easy to accomplish with cork oak, whether through grafting or cuttings, although some success was finally achieved at Alcobaça. Thanks to these experiments, "we can obtain genetically homogeneous cork oak populations, even with populations composed of individuals with a high degree of heterozygosis."[44]

Vieira Natividade viewed heredity as something that could be analytically assessed at an individual level through measurable performance of certain key traits. He coordinated the selection of these "plus trees" on the basis of the quality of cork, and selected trees were registered in the principal cork oak–producing areas in the country. Other parameters were taken into consideration, such as resistance to insects and diseases, and the straightness of the grain in the cork. The perspective resembled a pure line concept similar to Louis de Vilmorin's "pedigree breeding": "in Portugal there are no cork forests but rather cork orchards. The trees are pruned and carefully selected, inferior specimens being systematically removed."[45] Pedigrees help in selection of better parents for breeding and in monitoring inbreeding. Researchers at Alcobaça would claim that the principal value of their work lay in pedigree selection, which, contrary to mass selection, made relatively pure lines of

43. Joaquim Vieira Natividade, "Dez anos de estudo do sobreiro," *Boletim Cortiça*, no. 36 (1941): 8.

44. Joaquim Vieira Natividade, "A técnica ao serviço do problema corticeiro," *Boletim Cortiça*, no. 19 (1940): 9.

45. Ibid., 2.

heredity possible. According to them, properly scientific individual selection could produce stability, since it relied on the botanical specificities of cork oak reproduced through multiple generations.

After carefully selecting a single, especially well-suited mother plant with the desired traits, individual selection allowed one to derive an entire variety from a single plant. Louis de Vilmorin (1816–1860) pioneered and systematized the technique, which consisted of selecting individuals (rather than populations) as the starting point for a new breed, and then documenting "a perfectly correct genealogy of all my plants, right from the start of the experiment."[46] Although common in animal breeding since the eighteenth century, this idea was completely new in plant breeding.

He insisted on using quantitative methods. The desired property had to be measured with precision, and comparisons had to be analyzed in a statistical way. He noted that the progeny of individuals was sometimes homogeneous and sometimes highly variable, and he suggested that not only high-performance types, but also lines with minimum variability, should be bred. Disciplining plants into a stable "inner" genetic identity helped standardize their behavior and turn them into reagents that could help measure other "external" parameters. The neutralization of individual variation became a precondition to separate "the influence of heredity" from "external influences" (climate, farming practices, etc.), two categories of causes that were separated and whose relation was conceived as additive rather than interactive. Vegetative propagation, "without being a breeding process, can complete it."[47]

As the Portuguese cork sector moved from a cottage industry to an industrial enterprise, the building of trust required, for the first time, serious new standards. The JNC was guiding and inspecting the entire trade and seeing that official regulations were being observed. The quest for purity was also related to a challenge in quality management in large-scale cork production; "in no other country are the standards of production and marketing organization so developed."[48] The Portuguese cork trade had to meet the challenge of quality standardization and control to improve its position. To ensure the quality of the cork commercialized Vieira Natividade controlled quality upstream at the stage of tree multiplication, the vegetative propagation. Ideally,

46. Bonneuil, "Mendelism" (ref. 10), 287; Jean Gayon and D. Zallen D., "The Role of the Vilmorin Company in the Promotion and Diffusion of the Experimental Science of Heredity in France, 1840–1920," *JHB* 31 (1998): 241–262.

47. Guerreiro, "Sobre o problema" (ref. 37), 155.

48. Vieira Natividade, *Portugal* (ref. 26), 1.

tree production could be done at the Vimeiro national forest by skilled, disciplined, and carefully managed foresters. The Alcobaça Station thus developed pedigree breeding techniques and pure lines as the mainstay of a wider industrial strategy to streamline the mass production of cork along the principles of standardization and economies of scale.

By speaking of cork orchards, Vieira Natividade conceals the human work of developing landraces. In a modernist conception passed down from Nicolai Vavilov, another John Innes scholar, landraces comprise "gene reservoirs" and "genetic resources" inherited from the past. The concept of "genetic resource" implied a view of crop diversity as a standing reserve, which local farmers hardly knew how to harness. "Genetic resources" from the past needed to be prospected and assembled (including through interspecies artificial crosses) by scientists into new, modern cultivars. Far from the evolutionary genetics of its time, Vieira Natividade focused on the fixity and predictability of plant life forms. It assigned an important place to the requirement of "distinctive characters," "homogeneity," and "stability." The uniform and stable variety was an essential feature of the specific experimental and statistical culture of forestry and its mode of studying a few parameters separately. It was also an industrial object, that is, a predictable and standardized factor in an industrialized system of cork production.

In the context of Vieira Natividade's experimental culture and the new task he assigned to the state—that is, to distribute "genetic improvement" rationally throughout the national territory—"clones" appeared neither as the key scientific unit nor as the relevant object for intervention and regulation. He understood that in order to breed better adapted varieties, we should study and use the total genetic diversity of the plants themselves, including related wild species. The idea of studying and using plant diversity may have come to Vieira Natividade's mind from collecting expeditions, where he found highly disease-resistant species of trees, such as chestnut trees resistant to the "ink-disease."[49]

Plant geneticists such as Vieira Natividade collected a wide range of "genetic resources" at Alcobaça through exchanges with Portuguese forest owners and foreign institutions. Through this process, cork oaks from all over Portugal were extracted from the local cycles of growing and stripping, and grown in a different, experimental way at the Station, where they were sorted into types

49. In 1944, Vieira Natividade's team planted 688 kilos of chestnuts (50,000 plants) in the Vimeiro forest. Joaquim Vieira Natividade, *Em defesa do castanheiro* (Lisboa: Junta Nacional das Frutas, 1945), 24.

and varieties, planted alongside one another, transformed into pure lines by pedigree breeding, and recorded in cultivar registers and inventories. The notion of experimental systems helps us to understand how the different purposes and different experimental systems of plant breeding generated different scientific objects, different units of analysis, and different modes of manipulation. Cork oak breeders designed an experimental space that was populated by thousands of individuals and hundreds of traits, which they could study and upon which they could intervene. What these breeders aimed to do was to harness a vast genetic lottery and then sort it out, thereby assessing hundreds of potentially interesting new combinations. Designing an experimental system that would handle this vast genetic lottery implied five key elements.

First of all, it would be necessary to gather in one space the greatest genetic diversity for the greatest number of characters. By 1950, the Vimeiro forest possessed one of the largest cork oak collections in the world, containing a huge number of varieties, accumulated through voyages of exploration, participation in international fairs, and a dense network of correspondents who gathered and dispatched landraces.[50]

The knowledge and techniques needed to optimize the intermixing of genomes and the continuous production of new combinations constitute a second key step. Just as the experimental system of Morgan's group, the *Drosophila* mutation breeders,[51] was designed to produce hundreds of new forms from single mutations that could be isolated (and their loci "mapped"), the cork oak plant breeders' experimental system was designed to produce hundreds of new forms via continuous flows and infinite combinations of alleles. It is for this reason that Alcobaça breeders studied the biology of tree reproduction as a way to improve the rate of success of artificial crosses, and that the better equipped among them conducted artificial crosses on a large scale.

Improvements in the efficiency of the methods for screening such intermixed populations represent a third key element of the breeders' experimental culture. Efficient breeding meant improving the means for identifying potentially interesting individual plants among large populations. For this job, the "art" or "good eye" of the breeder—consistently identified by breeders as being

50. In 1933, Vieira Natividade received Quercus seed from several English Botanic Gardens, with the help of other Portuguese engineers studying there. Branquilho de Oliveira letter to Vieira Natividade from Cambridge, 20 May 1933, Vieira Natividade files, Alcobaça Public Library.

51. Bonneuil, "Mendelism" (ref. 10), 282.

crucial to their practice—was the key element. With the cork oak, only after the second cork stripping, when the cork oak was more than forty years old, could the forest owner or the breeder see easily the quality of the individual. The skill was initially developed by wandering through the plots and spotting valuable plants. New tools became available, along with new ways of organizing the work more systematically: performing large-scale biometrical analyses, the systematic inscription of observations in breeding notebooks, and the refinement of the taxonomical gaze capable of subdividing a population of a variety into many smaller and purer varieties, a technique pioneered at the Svalöv Station in Sweden and studied by Victoria Pires in 1934. The discipline of the breeder's expert body and the use of inscription and description devices might have been as crucial to the success of plant breeding as the introduction of Mendel's laws.

Fourth, once candidate plants (numbering in their hundreds) had been spotted as potentially interesting, they were subjected to inbreeding (pedigree selection) and became fairly pure lines or, in the words of Vieira Natividade, "one of the conquests of the forest scientist."[52] The "purity" of these lines was not checked through a direct estimation of their homozygosis but rather at the phenotypic level on the basis of taxonomical, biometrical, and agronomic data. For breeders, a satisfyingly pure line was an entity that was stable and uniform enough to produce robust results in properly conducted forestry experiments, offering "the quickest way to raise the value of the cork oaks of tomorrow . . . We already have the tools needed to build the cork oak of the future."

Assessing and comparing hundreds of lines to select a few of them as commercial products were the final key elements of the cork oak breeders' experimental system. This belonged to the long tradition of the agricultural assay. Since the late nineteenth century, this activity had been improved through a systematic homogenization of nature and human operations. Improvements were also obtained through an increased use of the statistical methods and methodologies of experimentation (repetition, analysis of variance and probable error, tests of significance, etc.). This fifth element of breeders' experimental culture was a decisive force in producing robust data on the forestry value of various varieties, allowing researchers to offer more consistent advice to both forest owners and the FNS, and to establish trust in a growing seed and tree market.

52. Vieira Natividade, "A técnica ao serviço" (ref. 44), 12.

THE 1950S CORK OAK PLANTATIONS AND THE *SUBERICULTURA* TRANSLATIONS

From 1934 to 1950, geneticists working at Alcobaça tested a number of varieties and, principally from 1955, distributed the successful ones among forest owners. The NFS tree nurseries produced thousands of seedlings. When integrated into a cork oak stand in the Alemtejo region, however, these discrete organisms became part of a complex system designed for a purpose. Moving from nursery to forest, foresters tried to construct complexity out of rational components, a biological machine whose whole was greater than the sum of its parts. Yet in important ways the forest also built itself, becoming a system in which technology and ecology were seamlessly integrated. Composed equally of human culture (labor, technology, science) and nature (soil, climate, plants, and animals), the product of this system was not merely wood or cork but the forest as a whole, a self-perpetuating technological ecosystem.[53]

The Alcobaça Station had to test the quality of the new trees. From 1955, more stringent distribution of plants by the National Cork Board gave Alcobaça's geneticists a central role in national cork production. Geneticists, in turn, provided the Board with material arguments for their struggle for power. Alcobaça scientists became a more active and integral to the corporate system. These activities made them key actors in cork oak standardization and homogenization in the service of the Estado Novo. The Alcobaça Station benefitted from the JNC's resources and from its new links with forest owners and industries, as the JNC assumed the tasks of consultancy, education, and inspection. These links among scientists, producers, and the state would be much stronger with the entry of Brito dos Santos in the technical service of the Board from 1946.

Artificial breeding combined with genealogical selection allowed Alcobaça's breeders to obtain homogenous varieties of particular interest, the plus cork oaks. In addition to allowing the practical eradication of such genetic variations as thin cork (disliked by the cork industrialy), homogeneity could bring numerous harvesting efficiencies, such as a shorter cycle of reproduction. It also reduced costs. If all plants matured at around the same time, stripping labor would be more predictable for forest owners, easier to organize, and require fewer working hours.

53. Robert Gardner, "Constructing a Technological Forest: Nature, Culture, and Tree-Planting in the Nebraska Sand Hills," *Environmental History*, 14 (2009): 275–297, 277.

Who planted Alcobaça's cork oaks in Portugal? Reforestation practices have deep roots in Portuguese forest policies.[54] We know that Vieira Natividade maintained a close friendship with at least two important forest owners, José Meneres and Joao Lopes Fernandes (1905–1973). The relationship between science and forest owners was developed in part through the articles published by the Alcobaça foresters in the JNC review, *Boletim Cortiça*. Also, some of the tree owners had large country estates and belonged to a wealthy class of forest entrepreneurs, among the major landlords "who have owned much of the agricultural land in the Mediterranean world."[55] Some of them considered themselves as agents of modernization and managed their farms in line with rational principles. They were interested in science and technology, and keen to experiment; they wanted to plant Alcobaça cultivars, and in important quantities.[56] As representatives of the rural elite, they were committed to politics and were opinion leaders in agricultural societies. Within the group of large landholders who had a strong influence on politics in Portugal, they represented the most progressive branch. Vieira Natividade, Meneres, and Lopes Fernandes organized several field trials to evaluate the performance of new plantations and management techniques. In Vieira Natividade's words, Lopes Fernandes considered his scientist friend a sort of "priest of magical arts" (Fig. 3).[57] Vieira Natividade considered his rich friend "a curious man, friend of the tree, simple and modest, with long vision, the group of qualities very rare on that that I call the Homo Latifundarius."[58]

Meneres' and Lopes Fernandes' new plantations followed the guidelines marked by some of Vieira Natividade's technical texts. The book *Subericultura*,

54. Cristina Joanaz de Melo, *Contras cheias e tempestades. Consciência do território, debate parlamentar e políticas de águas e de florestas em Portugal 1852–1886* (Phd dissertation, Florence, European Institute, 2010).

55. John Robert Macneill, *The Mountains of the Mediterranean World: An Environmental History* (Cambridge: Cambridge University Press, 1992), 106.

56. Joaquim Vieira Natividade, "Devoção subericola. As herdades de Leitões e Montalvo do Sr. Joao Lopes Fernandes," *Boletim Cortiça* 228 (1957): 341–352. In 1955, Meneses planted 51,000 kilos of cork oak acorns, "the biggest acorn plantation in any private Forest until the date"; Joaquim Vieira Natividade, "Sobreirais alpestres do nordeste de Portugal," *Naturalia*, 13 (1957): 38–42, 42.

57. Vieira Natividade letter to Meneres, 7 Dec 1957, Vieira Natividade files, Alcobaça Public Library. In that year Lopes Fernandes offered to Vieira Natividade a brand new car, a Mercedes 190. The scientist had refused any payment for years, but was obliged to accept this useful present.

58. Vieira Natividade letter to Meneres, 26 Aug 1957, Vieira Natividade files, Alcobaça Public Library.

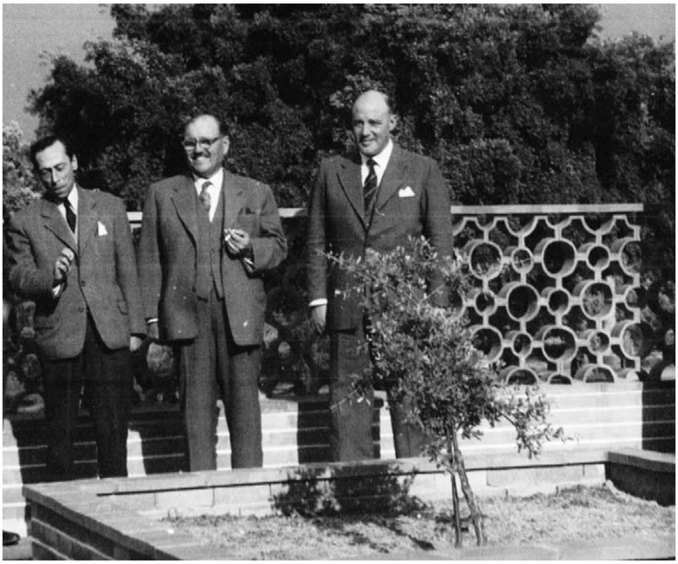


FIGURE 3. Vieira Natividade, Lopes Fernandes, and professor António Sardinha de Oliveira, Herdade dos Leitoes, 1950s. Natividade files, Alcobaça public library.

offering technical help to cork oak forestation problems, was at the same time the first original study in forest genetics from Spain and Portugal to reach the international community. In the following years other European forest scientists such as Aldo Pavari and Philibert Guinier reported Vieira Natividade's data and conclusions.

Like Aurelio Quintanilha, Vieira Natividade seems to have condemned the social and political regime on at least two occasions.[59] But in contrast with Quintanilha, the forester did not appreciate being involved in social and political activities. He made no exception in 1947, when a group of university professors, among them the forestry teacher Azevedo Gomes, endorsed the

59. García-Pereda, *Joaquim Vieira Natividade* (ref. 27), 70. Salazar's mission allowed him to use violence to crush political dissenters. The biography of Aurélio Quintanilha (1892–1987) seems to confirm the traditional narrative about the difficulties of conducting scientific research under authoritarian fascist-type regimes. Expelled from the Portuguese university system in 1935, he was finally recruited in 1943 by the Board of Export of the Colonial Cotton Board, which was willing to create a Center for Cotton Research in Mozambique. Quintanilha was thus sent to a far-away post, isolated from the political intrigues of the metropolis, following the regime's policy of sending opposition members to the African Colonies. Guerreiro's move to Mozambique in 1959 would be somewhat similar.

petition for free elections. Azevedo Gomes' ISA position was suspended in 1947, and until 1953, he was forbidden to come back to the University or to participate in any scientific meetings abroad.[60]

In May 1950, the Portuguese forester present at the FAO's Mediterranean Forestry Commission, in Algiers, was not Azevedo Gomes but Vieira Natividade. Vieira Natividade had become a major force in the world of Mediterranean forestry science. With seven foresters having studied under him, he had created the largest school of its kind among the Mediterranean foresters. In the Mediterranean basin, *Subericultura* would be widely acclaimed, and the French and the Spanish hosted him like a dignitary on several occasions. He had completed a masterful forestry treatise, turning an uncontrollable wealth of observation into a fledgling science. *Subericultura* was a major publication and was translated into French, Italian, and Spanish.

The 1950's meeting in Algiers would not be the last of the United Nations Mediterranean Forestry Commission meetings. An International Cork Oak Group was created, and the first meeting took place in Lisbon in 1951. Outstanding foresters such as Salvador Robles Trueba of Spain and André Metro of France[61] traveled to the Portuguese capital. Metro, with some years experience in the French cork oak forests of Morocco, would propose at this meeting the coordination of the French translation of *Subericultura*. But if the French foresters decided to translate this important text quite soon, the Italians would do the same some years later. The Portuguese text was not their only model for forestry practices; they took the Alcobaça Station as a model for a new Italian Cork Oak Station, the Stazione Sperimentale del Sughero, based on Tempio Pausania and inaugurated in 1960.[62] Vieira Natividade's international reputation was a unique asset for establishing international relationships. He continued correspondence with foresters from around the Mediterranean basin throughout his lifetime. His participation in the FAO meetings both reinforced and enhanced his position in the global network of forestry exchange. This in turn enlarged the audience for his work.

60. García-Pereda, *Mário de Azevedo Gomes* (ref. 21), 85.

61. André Metro, "Compte rendu de mission au Portugal," *Annales de la recherche forestière au Maroc* (1952).

62. Vieira Natividade, *Subériculture* (ref. 42); Joaquim Vieira Natividade, *Sughericoltura* (Sardegna: Assessorato Agricoltura e Foreste, 1960); Joaquim Vieira Natividade, *Subericultura* (Madrid: Ministerio de Agricultura, Pesca y Alimentación, 1991.)

CONCLUDING REMARKS

The establishment of forest genetics as a field of research in Portugal from the 1930s onward could scarcely be understood without taking into account the role played by Vieira Natividade. Similar to Edward Swain in Australia,[63] Vieira Natividade offered a broad vision of forestry that combined ecology, economics, and management. State forestry in Portugal was developing out of a complex set of actors and forces. What could genetics add to cork production in Portugal? Better cork quality, at a time when the Spanish and the French cork sectors were suffering two different wars. This history provides a material tool for examining engineers' agency in the shaping of Salazar's regime and the Estado Novo landscape. The histories of these cork oaks are functional representatives of more general developments, such as the political economy of industrialization, transformations of landscapes, vertical unions, and the consolidation of the regulatory state. The history of the Alcobaça Forest Station is an important example of fascist institution building.

Part of the explanation for the comparative institutional strength of Portuguese forest genetics lies in the higher rates of institutional expansion that occurred in the 1930s, a lost opportunity for other fascist cork producers in Spain.[64] The large scale of intervention was no longer a matter of sporadic control over the cork trade; by using corporate enforcement of professional discipline, and providing the technical ideology that legitimized it, the JNC and the NFS established a regime of ongoing control over forest owners and cork industries, and tightly controlled the state (and professional) technocratic planning of the distribution of plant genotypes throughout the national territory. The uniform and stable variety was an industrial predicate—being regarded as a predictable and standardized factor in an industrialized form of forest production system.

In Portugal, between 1930 and 1950, Vieira Natividade trained seven forest scientists. Some of them, such as Guerreiro, Machado, and Luis Seabra,[65]

63. Gregory A. Barton and Brett M. Bennett, "Edward Harold Fulcher Swain's Vision of Forest Modernity," *Intellectual History Review* 21, no. 2 (2011): 135–150.

64. The first public Spanish cork laboratory was created in 1967, the Laboratorio de Ensayos Físico-Mecánicos del Corcho y sus Manufacturas in Madrid.

65. Domingos Pereira Machado, "La sylviculture accelerée: L'amélioration génétique et l'augmentation de la productivité forestière au Portugal," *Actas Sexto congreso forestal mundial* (1966): 2460–2500; Luis Santos Viegas Seabra and Manuel Pinheiro Ferreirinha, "Maderas Colonias," *Estudos, Ensaios e Documentos*, no. 6 (Lisboa: Junta de Investigacoes Coloniais, 1950).

became the heads of new forestry science institutions in the 1950s, such as the Instituto de Investigaçao Cientifica (Mozambique, 1959) and the Tropical Wood Technology Laboratory (Lisbon, 1948). Another institutional advantage of importance to Portuguese forest genetics was the natural interest in the discipline of forest owners and breeders who, though not always sympathetic to basic genetic research, nevertheless generally supported the Alcobaça Station. The European foresters caught the significance of the gathering institutional power of Vieira Natividade's work when they decided to translate his book *Subericultura* in several countries.

Vieira Natividade resigned as head of the Cork Oak Station in 1950, and in 1956, the NFS transformed the Alcobaça laboratory into a subsection of a new Biological Forestry Station, Estaçao de Biologia Florestal, headquartered at the Lisbon Forest Services headquarters. Guerreiro would leave for Africa in 1959, but the Alcobaça cork oak experiments would go on at Alcobaça in the hands of the forester Carlos Alberto da Paixao Correia, married to one of Vieira Natividade's nieces. Forestry science still happened at Alcobaça until 2002, when the last of the Alcobaça foresters, Dario Reimao, had to leave Vieira Natividade's birth town. Throughout his career Paixao Correia never stopped the cork oak vegetative propagation experiments "for the establishment of new clone lines."[66] Paixao Correia used bud grafting to establish a small single clone plot, but this method requires very skilled workers.[67] In 1982, he was still the reference for the first Spanish forest scientists studying the problems of cork oak breeding. The Spanish forester Pardos Carrión was looking for previously selected "plus cork oaks," and with vegetative propagation problems, he would go on to use one of the Paixao Correia's successful techniques, "la técnica de los ramos amontonados, lo que llamamos aporcamiento" (stimulated grafting of cork oak to other oak stocks).[68]

Although the Alcobaça experimental station had provided the model for their Mediterranean counterparts, the Portuguese station's research reputation declined from the end of the 1950s. The dissolution of the research team at the

66. Carlos Alberto Paixao Correia, "Quelques notes sur le développement radiculaire et aérien du chêne-liège (Quercus suber l) pendant la phase juvénile," *Actas Sexto congreso forestal mundial* (1966): 2566–2569, 2566.

67. Margarida Alpuim and Maria Isabel Roldao, "Quercus suber L breeding strategy for cork quality," *Annales sciences forestières* 50, suppl. 1 (1993): 444–447, 447.

68. José Antonio Pardos Carrión, "Hacia una mejora genética del alcornoque," *Actas Convención mundial del Corcho 1980* (Madrid: Servicio de Publicaciones Agrarias del MAPA, 1982), 92–97, 96.

Alcobaça Station, before and after Vieira Natividade's departure, was the result not only of a lack of scientific projects or the initiative of its leaders and members. Difficulties within the NFS in imposing a new research ethos, as in the Lisbon Laboratory of Physics,[69] proved crucial to account for Vieira Natividade's fate. In fact, although the Station was successful in establishing productive links with foreign scientists, a fact corroborated by Chesneau's 1947 visit, it proved unsuccessful in establishing better connections within its immediate administration.

Since the 1920s, the Portuguese NFS was seriously engaged in research to such an extent that its leaders, such as Mendes de Almeida, played a leading role in campaigning for research. One of its outcomes materialized in the government's investment in forestry research institutions, in tune with its policy of providing the agriculture and forestry system with adequate personnel. Vieira Natividade profited from these measures. What was unique about the Portuguese foresters was their privileged positioning in the context of the new state. The new regime offered the chance to develop their projects away from the ups and downs of parliamentary politics. Although their expectations were often stymied by lack of resources, their involvement in the quest for national production made them key actors within the regime. Their role as mid-level decision makers is particularly relevant to this story. Together with administrators they turned research in a strategic area into a state priority. In examining the circulation of products such as cork oaks, engineers emerge as agents of landscape transformation. As environment historians have shown, remaking landscapes is a political enterprise.[70]

With the support of JNC, Vieira Natividade built the first successful forest genetics research school in the Iberian Peninsula. He was a keen promoter of science; from pure line cork oak races to the chaotic variability in the Portuguese forests, from a context marked by nationalistic ideas to an economics-driven university environment, Vieira Natividade's research trajectory in Alcobaça is a striking testimony of the political changes operating in Portugal during the early phase of the New State. By combining and recombining plants, plant material, and plant information, Vieira Natividade was able to take a key position in influencing the way Portugal was forested. The most

69. Júlia Gaspar and Ana Simões, "A Research School at the University of Lisbon under Salazar's Dictatorship,"*HSNS* 41, no. 3 (2011): 303–343, 339.

70. Chris Pearson, *Scarred Landscapes: War and Nature in Vichy France* (Hampshire, UK: Palgrave MacMillan (2008).

striking materialization of this possibility was the "plus cork oaks" prepared in the vegetative propagation working line. They were as much a laboratory artifact as a commodity for Portuguese political economy. The original, albeit modest, scientific research conducted at the Cork Oak Station was not only strongly linked to forest production, but also, and more particularly, was dependent on the vertical integration of Portuguese cork production, which in turn, was fed by research on young trees. Rather than depending on a large budget, the Station's successes depended on the state organization. The JNC relied on the Station for acquiring the plants it distributed in the forestation plans.

After 1930, and spreading across a twenty-year period, institutions of applied sciences such as the EAN or the Alcobaça Station, together with organizations of economic coordination such as the National Cork Board, were set up whenever the pressure for economic and social development was strongly felt. From the start, genetics were decisive for the Estado Novo government, and the Alcobaça Station became a model for the future organization of other countries' applied forestry research centers. In fact, an investment in scientific and technical training was deemed to be an asset for the country's modernization, and the Alcobaça Station benefitted the most from it.

Some members of the agro-forestry community, such as Azevedo Gomes and Quintanilha, suffered political persecution for publicly disagreeing with the regime's policy. By contrast, scientists or engineers such as Antonio Câmara were admirers of the dictator Salazar and were deeply committed to the politico-scientific agenda of the regime. Câmara adopted one Salazar sentence as motto of the EAN.[71] But this did not mean they could not, at times, be critical of the regime's decisions.

In the context of a dictatorship, scientific groups were often heavily dependent on charismatic leaders, and in the same way political agendas were often dependent on the ideas of individual politicians. In Portuguese forest genetics, this was the case with Joaquim Vieira Natividade. Without doubt, Vieira Natividade lent a visible profile to science at a time when few Portuguese scientists or engineers enjoyed public prominence. Two conspicuous events contributed to his visibility and reputation: his admission to the Portuguese Academy of Science in 1955, and a well-publicized lecture delivered in 1966,

71. "Estudar na dúvida, realizar na Fé" (Study in the doubt, make in the faith). António Câmara, *Planos de Trabalho da Estaçao Agronomica Nacional* (Lisboa: Ministerio da Agricultura, 1939), 32.

when he won the Honoris Causa PhD at Toulouse University. On each occasion, he was seen as an intellectual representative of the Salazar regime. During the Estado Novo period, working in an atmosphere that was at times overtly hostile to science, he led a successful career—not least because he rested his case on a firm belief in the values of science over the appeal of political contingency. Vieira Natividade benefitted in no small way from the Salazar regime, which promoted the areas in which he worked. Nevertheless, cooperation—some would say, collaboration—did not destroy his autonomy. His support for the regime lent Salazar international prestige, but also helped sustain Portuguese science during its long period. In Portugal, the struggle for democracy is often seen in terms of an oversimplified struggle between dictatorship and democrats. However, Vieira Natividade's experience underlines the complexity of the situation.

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