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THE TRANSFORMATION OF AGRICULTURAL RESEARCH IN FRANCE: THE INTRODUCTION OF THE AMERICAN SYSTEM

ABSTRACT. In 1916, French entomologist Paul Marchal published a seminal report on the contemporary state of agricultural research in the United States of America. His recommendations underlined the need for a close relationship between research and education, a factor vital to national survival in the aftermath of the Great War. This essay discusses the context of this report, and assesses its consequences for government policy towards agricultural research and education in France.

INTRODUCTION

In 1916, a year of inconsolable death on the Western Front, French science welcomed a publication that was to prove no less significant to life on the Home Front. In the well-read pages of the relatively little known *Annales des épiphyties* appeared a 300-page report on agricultural research in the United States of America. This report, entitled 'Les sciences biologiques appliquées à l'agriculture et la lutte contre les ennemis des plantes aux États-Unis', described a journey through America made in 1913 by the French economic entomologist, Paul Marchal (1862–1942).[1] Invited by Leland Ollian Howard, chief entomologist of the US Department of Agriculture (USDA), Marchal toured several universities, agricultural colleges, state experiment stations, and the agencies of the USDA. Marchal described how the USA, in combining agricultural education and research, had achieved unparalleled success in the production of food.[2] Appearing in the midst of war, and at a time of vital concern for food supplies, 'Les sciences biologiques' was to

[1] Paul Marchal, 'Les sciences biologiques appliquées à l'agriculture et la lutte contre les ennemis des plantes aux États-Unis', *Annales des épiphyties*, 3 (1916), 31–380.

[2] On the use of foreign example to modify local institutions, see Christophe Charles, 'Les références étrangères des universitaires', *Actes de la recherche en sciences sociales*, 148 (2003), 8–19, and Claude Schnitter, 'Thèse et controverses autour d'une périodisation – l'âge d'or et le déclin de la science en France au XIXe siècle: l'exemple du Muséum d'Histoire Naturelle de Paris' (Unpublished doctoral dissertation, Université de Paris VII, 1995).

become the first in a series of studies, published between 1914 and 1922, that framed a new vision of agricultural research for France.[3] Ultimately, it was to contribute to the establishment in 1921 of the Institut de Recherches Agronomiques and to the Institut National de la Recherche Agronomique, created in 1946, which survives to this day.[4]

According to Deborah Fitzgerald, the most important innovation in agriculture during the twentieth century was the application of the American research system.[5] The most compelling feature of this system was its encouragement of close working relationships between experiment stations and agricultural colleges.[6] Appearing when it did, Marchal's report upset the prevailing wisdom, by which France had cast Germany, and not the USA, as its role model for scientific research.[7] In earlier decades, young American scientists had indeed studied in the laboratories of Germany, but by 1900, an identifiably American system had come into its own.[8] Moreover, in American hands, the field of agricultural chemistry – a discipline traditionally led by Germany – was giving way to a new interest in the fields of agricultural biology, including genetics, animal nutrition, and plant physiology.[9] Because the USA had taken this 'biological turn' before Europe, the American system seemed to offer more to the reform of agriculture in France.

[3] Georges Wéry, *Les établissements scientifiques de recherches agricoles en France et à l'étranger* (Paris: Société d'Encouragement pour l'Industrie Nationale, 1918); Eugène Tisserand, 'Rapport sur les établissements agricoles de recherche scientifique: Ce qu'ils font, ce qu'ils devraient être', *Compte rendu hebdomadaire des séances de l'Académie des Sciences*, 163 (20 November 1916), 621; 163 (4 December 1916), 722. See also Maurice Caullery, *Universities and Scientific Life in the United States* (Cambridge, MA: Harvard University Press, 1922).

[4] On the relationships between the Institut de Recherches Agronomiques and the Institut National de la Recherche Agronomique, see Jean Cranney, *L'INRA, 50 ans d'un organisme de recherche* (Paris: INRA, 1996).

[5] Deborah Fitzgerald, 'Mastering Nature and Yeoman: Agricultural Science in the Twentieth Century', in John Krige and Dominique Pestre (eds.), *Science in the Twentieth Century* (Amsterdam: Harwood, 1997), 701–713.

[6] Margaret Rossiter has shown how that link facilitated a rapid growth of agricultural scientific institutions in the USA. See Margaret W. Rossiter, 'The Organization of the Agricultural Sciences', in Alexandra Oleson and John Voss (eds.), *The Organization of Knowledge in Modern America* (Baltimore: Johns Hopkins University Press, 1979), 211–248.

[7] Nathalie Jas, *Au carrefour de la chimie et de l'agriculture: Les sciences agronomiques en France et en Allemagne 1850–1914* (Paris: Éditions des Archives Contemporaines, 2001).

[8] Margaret W. Rossiter, *The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840–1880* (New Haven: Yale University Press, 1975), especially 186–195.

[9] Jas, *op. cit.* note 7, 342–388. On developments in American agricultural biology, see Barbara Ann Kimmelman, 'A Progressive Era Discipline: Genetics at American Agricultural Colleges and Experiment Stations, 1900–1920' (Unpublished doctoral dissertation, University of Pennsylvania, 1987), and Rossiter, *op. cit.* note 6, 213.

AGRICULTURAL RESEARCH IN FRANCE

Historians have tied the slow modernization of French agriculture to a long process of evolving needs and capacities. Certainly, the modernization of rural France followed a special pathway – a 'French way' of development, in which science played a central role.[10] By the end of the nineteenth century, there were chairs in agricultural chemistry, botany and zoology at several provincial universities,[11] and these encouraged progressive farmers in the application of new techniques.[12] However, this progress was neither universal, nor systematic. Moreover, the educational system offered few avenues for the training of much-needed researchers (see Figure 1).

This regrettable fact was a consequence of the separation of powers between two of the most highly centralized and powerful ministries in France – the Ministère de l'Instruction Publique [Ministry of Public Instruction] and the Ministère de l'Agriculture [Ministry of Agriculture].[13] Whereas the former funded and controlled the universities (and their science faculties), the latter was responsible for agricultural instruction. In 1866, the Ministry of Public Instruction decided to include agricultural higher education as one of its responsibilities.[14] In reaction, the Ministry of Agriculture established a number of specialized schools – for horticulture in Versailles (1874), for the dairy industry in Mamirolle (1888), and for the agricultural industries in Douai (1893). It also reformed its Écoles Impériales, and renamed them the Écoles Nationales d'Agriculture (ÉNA). Finally, it implemented a division of labour that gave instruction in agricultural practice to its ÉNAs, but instruc-

[10] Patrick O'Brien and C. Keyder, 'Les voies de passage vers la société industrielle en Grande-Bretagne et en France', *Annales: Économies, sociétsé, civilisations*, 34 (6), (1979), 1284–1303; Nadine Vivier, 'L'agriculture française était-elle archaïque', *Historiens et géographes*, 82 (338), (1992), 112–130.

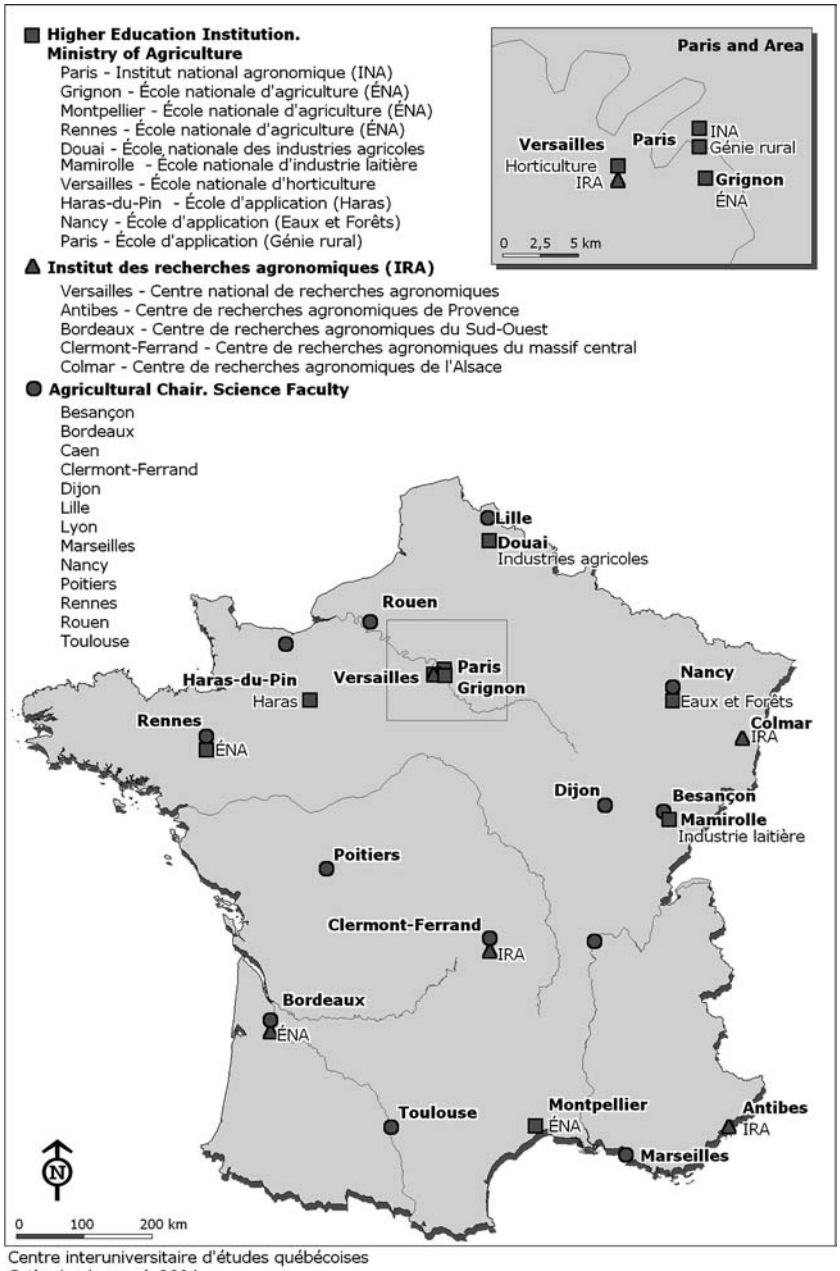
[11] Mary Jo Nye, *Science in the Provinces: Scientific Communities and Provincial Leadership in France, 1860–1930* (Berkeley: University of California Press, 1986); Harry W. Paul, *From Knowledge to Power: The Rise of the Science Empire in France, 1860–1939* (Cambridge: Cambridge University Press, 1985), 185; Thérèse Charmasson *et al.*, *L'Enseignement agricole et vétérinaire: De la Révolution à la Libération: Textes officiels avec introduction, notes et annexes* (Paris: Publications de la Sorbonne, 1992), lxxxix.

[12] Jas, *op. cit.* note 7, 338–340.

[13] As in many other countries, agriculture was previously attached and subservient to another department. In France, agriculture was separated from the Ministère du Commerce [Ministry of Trade] in 1882. See Georges Cusson, *Origines et évolutions du Ministère de l'Agriculture* (Paris: Presses Modernes, 1929).

[14] Charmasson *et al., op. cit.* note 11, lxxix.

Figure 1. Institutional Ecology of Agricultural Science in France



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tion in agricultural theory to the Institut National Agronomique (INA).[15]

Established at Versailles in 1848, the INA fell victim in 1852 to a decision by Napoleon III to dissolve institutions that were deemed too costly for the Second Empire. Nonetheless, during these four years, the INA trained an impressive generation of agronomists, including Eugene Tisserand (1830–1925). In 1872, Tisserand was commissioned by the Ministry of Agriculture to inquire into the state of agricultural education, at the same time that the Ministry of Public Instruction attempted to acquire responsibility for that domain.[16] Winning the support of rural notables, who sought to raise the prestige of agriculture, Tisserand appealed to the Government to reopen the INA, for the training of specialists to help 'modernize French agriculture and improve productivity'.[17] In 1876, the Third Republic agreed, and reinstated the INA, which was moved to central Paris, close to the Faculté des Sciences and the Muséum d'Histoire Naturelle.[18]

In the event, location proved less important than inclusion in the elitist circle of the *grandes écoles*.[19] Since their creation – beginning in the *Ancien Régime* – the *grandes écoles* had trained the senior *fonctionnaires* of France. Their curricula, emphasizing mathematical and analytical skills, enjoyed a special social prestige.[20] The INA, wishing its graduates to be on a par with those of the larger *grandes écoles*, instituted an entrance examination and curriculum that matched the standards set by professors who, for the most part, held joint appointments at the Muséum, the Pasteur Institute, the École des Mines, and the Collège de France.[21] Like the graduates of the other *grandes écoles*, the 'Agros' – as they

[15] *Ibid*., lxxxi-cxxii.

[16] Ministère de l'Agriculture, 'Rapport sur l'enseignement agricole en France, publié par ordre de M. Viger, Ministre de l'Agriculture. I, Rapport de M. Tisserand. Considérations générales et législation', *Annales de l'Institut National Agronomique*, 1 (1876–1877), 166–191.

[17] Marie Benedict Trocmé, 'Agriculture and Administrative Elites in Third Republic France: The Institut National Agronomique, 1876–1940' (Unpublished doctoral dissertation, New York University, 2000), 90.

[18] Eugène Tisserand, 'La réorganisation et la direction de l'Institut National Agronomique de 1876 à 1917', *Annales de l'Institut National Agronomique*, 20 (1927), 189.

[19] Benedict Trocmé, *op. cit*. note 17. On the *grandes écoles* and French society, see Pierre Bourdieu, *La noblesse d' État: Grandes écoles et esprit de corps* (Paris: Éditions de Minuit, 1989).

[20] Terry Shinn, 'Progress and Paradoxes in French Science and Technology', *Social Science Information*, 28 (4), (1989), 659–683.

[21] On the practice of 'cumul' in the French universities, see Robert Fox, 'Science, the University, and the State in Nineteenth-Century France', in Gerald L. Geison (ed.), *Professions and the French State, 1700–1900* (Philadelphia: University of Pennsylvania Press, 1984), 66–145.

were called – were accorded the diploma and status of *ingénieur agronome*.

The 'Agros' were destined to become a *corps d'État*.[22] However, few chose careers in science.[23] Little of the 'research spirit' was conveyed to them in a traditional curriculum – based on physics, chemistry, geology, and the agronomic sciences – by teachers who emphasized concepts and principles rather than analysis and application.[24] Nevertheless, the INA did build teaching laboratories,[25] and instituted a third year of study to encourage the best students to take up agricultural engineering, the natural sciences, animal husbandry, and crop science.[26] Indeed, the INA soon had more third year students than its modest facilities could accommodate. At first, these students went on to become professors or researchers at one of the Ministry of Agriculture's agronomic stations.[27] However, by 1900, their numbers had diminished, and few (only 6–7% of graduates prior to 1917) took up research positions.[28]

[22] On the relationship between the *grandes écoles* and the administration of France, see Bourdieu, *op. cit.* note 19.

[23] C.R. Day, 'Science, Applied Science and Higher Education in France 1870–1945: An Historiographical Survey since the 1950s', *Journal of Social History*, 26 (2), (1992), 367–384; Terry Shinn, 'The French Science Faculty System, 1808–1914: Institutional Change and Research Potential in Mathematics and the Physical Sciences', *Historical Studies in the Physical Sciences*, 10 (1979), 271.

[24] P. Régnard and G. Wéry, 'L'Institut National Agronomique de Paris', in *Documents et comptes-rendus du IIème Congrès international d'enseignement agricole, Liège – 28 et 29 juillet 1905* (Louvain: Polleunis et Ceuterick, 1905), 12–13.

[25] The INA owned an experimental farm in Joinville, outside Paris, and a plant pathology laboratory and entomological station were attached, respectively, to its chair of botany, and its chair of zoology applied to agriculture. See *L'Institut Agronomique et son enseignement pendant les vingt-cinq premières années de son existence, 1876–1901* (Paris: Baillière, 1901), 498–500, 539–542.

[26] G. Wéry, *L'Institut National Agronomique. Admission, enseignement, recherches, influence extérieur* (Paris: Librairie Agricole de la Maison Rustique, 1905).

[27] Benedict Trocmé, *op. cit.* note 17, 127–128. On French agronomic stations at the end of the nineteenth century, see Jas, *op. cit.* note 7, 325–330. Most of the agronomic stations (including those founded by a *département*) were under the jurisdiction of the Ministry of Agriculture, but the Ministry of Public Instruction, agricultural societies, and individuals also operated a few of them. See Louis Grandeau, 'État statistique des stations agronomiques et des laboratoires agricoles en 1902,' *Annales de la science agronomique française et étrangère*, 2nd Series, 8 (1902–1903), 448–470.

[28] 'Carrières ouvertes aux ingénieurs agronomes', in *L'Institut Agronomique et son enseignement, 1876–1926* (Paris: J.- B. Baillière et fils, 1927), 449. See also Archives Nationales (France), 3 INA 90 'Sections (Section d'application de mécanique agricole, section de perfectionnement pour les sciences appliquées à l'agriculture, 1920–1938)'.

Whereas the INA set out to produce an educated elite, it fell to the specialized and regional ÉNAs to promote best practice. In this respect, a school's location determined its curriculum. Thus, Montpellier specialized in viticulture; Grignon, in the field crops of northern France, and Rennes, in mixed farming, as well as in the dairy and apple industries.[29] At the ÉNAs, teachers aimed at preparing large land-owning farmers, not *purs savants*.[30] Nevertheless, in tending to mimic the central INA, the regional ÉNAs reinforced the INA's idea that all students needed a scientific background to improve production. In this respect, agricultural education did not differ from engineering, where, according to Terry Shinn, 'schools seeking to improve their status emulated the ideologically established and preserved features of the institutions located at the hierarchy's summit, instead of innovating curriculum [sic] and attempting to stimulate new career paths'.[31]

By 1900, the ÉNAs at Montpellier and Grignon possessed their own agronomic stations, distinct from those of the Ministry of Agriculture. These were staffed by scientists who helped local farmers by analyzing soil and plant samples, and by recommending fertilizers and methods of pest control.[32] However, the training of researchers was not within their purview. Indeed, their isolation from the metropolitan culture of research was reflected in the tendency to move to Paris to further their careers. Those INA and ÉNA *diplômés* who wished to obtain doctoral degrees could, in principle, enrol in the science faculties of the various provincial universities. However, as this could be inconvenient, many promising minds – 'Agros' were among the most scientifically literate French youth – were lost to science.

[29] Ministère du Commerce, de l'Industrie, des Postes et des Télégraphes, *Exposition universelle internationale de 1900 à Paris: Rapports du jury international. Classe 5: Enseignement spécial agricole* (Paris: Imprimerie Nationale, 1904), 223.

[30] Archives du Muséum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Fonds Louis Mangin, 'Rapport sur l'ensemble des services de l'enseignement et améliorations à y apporter', présenté par M. Gaston Bonnier au nom de la commission de réorganisation des écoles nationales d'agriculture, November 1922.

[31] Terry Shinn, 'The Genesis of French Industrial Research, 1880–1940', *Social Science Information*, 19 (3), (1980), 607–640, especially on 620.

[32] *L'École Nationale d'Agriculture de Montpellier: Enseignement, laboratoires, champs d'expériences, publications, action extérieure* (Montpellier: Coulet, 1900), 18; Édouard Griffon, 'Travaux de la station de physiologie et de pathologie des plantes cultivées', *Association amicale des anciens élèves de Grignon, Annales de Grignon*, 5 (1906–1907), 162.

Moreover, those who did take research degrees did not necessarily pursue agricultural subjects, given that their advisors typically worked in other disciplines, and not infrequently held agriculture in disdain.[33] There were exceptions, of course. In Paris, Alfred Giard, who held the Chaire d'Évolution des Êtres Organisés in the Faculté des Sciences, regularly published in applied entomology.[34] At the Faculté des Sciences in Toulouse, Albert Lécaillon directed a laboratory for research in applied entomology, while Adolphe Prunet, professor of agricultural botany, established a phytopathological station.[35] At the Faculté des Sciences in Rennes, Professor Frédéric Guitel set up an entomological laboratory in 1904.[36] Other universities also set up agronomic stations.[37] However, these efforts proved inadequate to the need of France for a continuing supply of applied entomologists and plant pathologists. Some provincial universities considered creating faculties of agriculture, but in so doing, they met opposition from the Ministry of Agriculture – dominated, ironically, by 'Agros' – claiming that university education was incompatible with agricultural practice.[38] Science faculties could promote the relevant sciences – or so went the argument – but only the ÉNAs and the INA could effectively expose students to rural realities.

[33] On the reaction of university professors to agricultural science, see René Worms, 'Enseignement agricole dans les universités', *Revue internationale de l'enseignement*, 42 (1901), 121–127; Bernard Trouvelot and Fernand Willaume *Au secours des sciences agronomiques. L'enseignement supérieur. Rapport sur l'organisation de leur enseignement supérieur. Projet de licence et de doctorat* ès *sciences agronomiques* (Paris: Meulan, 1928). An important exception was Louis Blaringhem (1878–1958), a geneticist involved in agricultural plant breeding who was also professor at the Paris Faculté des Sciences. See Marion Thomas, 'Louis Blaringhem (1878–1958): Un généticien néo-lamarckien', *Ruralia*, 8 (2001), 103–119.

[34] For a survey of Alfred Giard's publications in applied entomology, see the bibliography in M. Caullery and F. Le Dantec, 'Notice sur Giard', *Bulletin scientifique de la France et de la Belgique*, 42 (1909), xlv–lxxiii.

[35] Pierre Grison, *Chronique historique de la zoologie agricole française* (Paris: INRA, 1992), 60; G. Nicolas, 'A. Prunet', *Revue de pathologie végétale et d'entomologie agricole*, 17 (1), (1930), 2–14; and R. Morquer, 'Gustave Nicolas', *Mémoires publiés par la Société Botanique de France*, 37 (1–2), (1955), 79–95.

[36] F. Guitel, 'Sur la création d'une station entomologique à la Faculté des Sciences de Rennes', *Archives de zoologie expérimentale et générale*, 4th Series, 6 (4), (1907), 93–101; F. Guitel, 'La station entomologique de la Faculté des Sciences de Rennes depuis sa fondation', *Comptes rendus du Congrès des Sociétés Savantes de Paris et des Départements tenu à Rennes en 1909* (Paris: Imprimerie Nationale, 1909), 257–266.

[37] J. Beauverie, 'L'Enseignement supérieur agronomique dans les universités', *Bulletin de la Société des Sciences Naturelles de Saone-et-Loire*, New Series, 27 (February 1901), 54; and Ministère du Commerce, de l'Industrie, des Postes et des Télégraphes, *op. cit.* note 29, 44.

[38] Ministère du Commerce, de l'Industrie, des Postes et des Télégraphes, *op. cit.* note 29, 44.

In the event, the only option left to the provincial universities – which were centrally administered by the Ministry of Public Instruction – was to develop curricula of their own. These would give students a *brevet*, or certificate (or, in certain cases, a doctorate) in the agricultural sciences. However, these graduates could not readily compete with the *ingénieurs agronomes* or *ingénieurs agricoles* of the INA and ÉNAs. Given the prestige of the *ingénieur*, mere university graduates were forever at a professional disadvantage.

These territorial disputes between the Ministry of Agriculture and the Ministry of Public Instruction were aggravated by tensions between the central INA and the specialized ÉNAs. The INA insisted upon a division of labour, according to which the ÉNAs offered practical instruction, while the INA emphasized theory. At the INA, only third-year students and summer interns were actually exposed to farms. However, the major difference between the INA and the ENAs came in their admissions process – according to which the level of the mathematics requirement increased, on a rising scale from university, to ÉNA, to INA. Inversely, research-related curricula were left to the science faculties.

Well before 1914, the shortcomings of this situation were abundantly clear. With the coming of war, the need to bridge higher education and research became urgent. This was the scene that, in 1916, received the report of Paul Marchal.

Paul Marchal and Plant Protection

Paul Marchal was born in 1862 in Paris, where he attended the Lycée Condorcet, and took degrees in medicine (1890) and marine zoology (1892). The latter he obtained from the Faculté des Sciences in Paris, where he worked under Henri de Lacaze-Duthiers, a proponent of experimental zoology and founder of the French marine biological station (at Roscoff, Finistère).[39] In 1910, he became a

[39] On Marchal, see Paul Vayssière, 'Paul Marchal', *Annales de la Société Entomologique de France*, 111 (1942), 149–165; Charles Pérez, 'Notice sur Paul Marchal', *Compte rendu hebdomadaire des séances de l'Académie des Sciences*, 214 (1942), 449–452; Jean Feytaud, 'L'entomologie française depuis Réaumur. Henri Fabre et Paul Marchal', *Actes de l'Académie Nationale des Sciences, Belles-Lettres et Arts de Bordeaux*, 4th Series, 15 (1958), 1–18. On Lacaze-Duthiers and French biology, see H.W. Paul, 'L'idée de recherche dans les Facultés des Sciences au XIXe siècle', in Christophe Charles and Régine Ferré (eds.), *Le personnel de l'enseignement supérieur en France au XIXe et XXe siècles* (Paris: Éditions du CNRS, 1985), 219–227.

member of the Académie des Sciences, and in 1912, of the Académie d'Agriculture. His work attracted the attention of Paul Brocchi, professor of agricultural zoology at the INA, and director of its Paris Entomological Station. Hired in 1894 by Brocchi to be a *chef des travaux*, Marchal succeeded his supervisor in 1900, and in 1911 established a *Service d'Inspection Phytopathologique de la Production Horticole*, together with a number of entomological laboratories. In 1915, the Ministry of Agriculture combined these into a new *Service des Épiphyties*. The history of this new service became the central thread in Marchal's report, and in the transformations it presaged.

Well before the war, French agriculture was affected by developments across the Atlantic. In 1912, the US Congress passed a strict Plant Quarantine Act, which required the issuance of sanitary certificates for imported plant products. This act obliged many European countries to set up phytopathological services, both to perform the necessary inspections and to provide the necessary certification. France, facing a potentially disastrous embargo, was hard-pressed to respond, particularly since two very destructive insects – the gypsy moth and the brown-tail moth – had recently been traced to French nurseries.[40]

To meet this urgent challenge, the Government in May 1911 created a new inspection service to cover the whole of France. In each of thirteen 'phytosanitary districts', into which the country was divided, an entomologist or a plant pathologist from a regional ÉNA or science faculty was put in charge of inspecting and certifying nursery products destined for export. The same year, the Ministry of Agriculture established temporary entomological field stations in five wine-growing regions (Champagne, Bourgogne, Vallée de la Loire, Bordelais, and Midi). These stations participated in a '*mission cochylis-eudémis*' – an inquiry into an outbreak of two types of vine budworm that had reached epidemic proportions in 1910. The Paris Entomological Station of the INA collated regional reports on the outbreaks. Marchal headed both the mission and the inspection service, and set up field stations, manned by scientists from the ÉNAs and from provincial science faculties. In February 1912, the Ministry of Agriculture made these stations permanent, and gathered them into a new *Comité Consultatif des Épiphyties*.[41]

[40] On the brown-tail and gypsy moths in America, see Thomas Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton: Princeton University Press, 1981).

[41] 'Rapport pour l'année 1912: Mémoires et rapports présentés au Comité des épiphyties sur les travaux et les missions de 1912', *Annales des épiphyties*, 2 (1913), 4–5.

Because these stations were outside the jurisdiction of the Ministry of Public Instruction, and because the Ministry of Agriculture did not award research degrees, the *Service des Épiphyties* had no way of training phytopathologists or entomologists. How actually to train applied biologists remained a dilemma.

This was indeed the dilemma that preoccupied Marchal, who sailed to the USA in September 1912. Arriving in Washington, DC, he was greeted by Leland Howard, who, as chief of the US Department of Agriculture's Bureau of Entomology (USBE), had frequently welcomed European scientists. Their visits helped boost the prestige of American science and of his Bureau – a point that Howard made to the philanthropist Andrew Carnegie. In 1912, Carnegie paid for three British students to visit the USA 'to study the American system of organizing economic entomology';[42] the same year, he also paid the expenses of Karl Escherich, a German entomologist, whom Howard had invited.[43] There was an expectation that Escherich would, on returning home, 'write a report showing how far Germany is behind America in the matter of economic entomology'.[44] In a similar vein, Howard sought – and obtained – Carnegie's support for Marchal.[45]

For Howard, European visitors also served an important political function. At this time, his Bureau was engaged in a bureaucratic struggle with the rival Bureau of Plant Industry (BPI).[46] Besides their administrative differences lay important differences in priority and perspective. In Europe, phytopathology was viewed as an applied discipline, superior in importance to entomology. Dam-

[42] L.O. Howard, 'A History of Applied Entomology (Somewhat anecdotal)', *Smithsonian Miscellaneous Collections*, 84 (1930), 223–224; National Archives and Records Administration (USA), Records of the Bureau of Entomology and Plant Quarantine, RG–7, E–34, General Records. General Correspondence 1908–1924 (hereafter NAUSBE), Box 132, file 'A. Carnegie', *Minutes of the Meeting of the Selection Sub-Committee of the Entomological Committee held at the Colonial Office*, 23 September 1910; Lord Cromer to Carnegie, 27 October 1910.

[43] NAUSBE, Box 132, file 'A. Carnegie', L.O. Howard to A. Carnegie, 19 May 1911; A. Carnegie to L.O. Howard, 14 June 1911; L.O. Howard to A. Carnegie, 3 January 1912.

[44] NAUSBE, Box 132, file 'A. Carnegie', L.O. Howard to A. Carnegie, 19 May 1911. See K. Escherich, *Die Angewandte Entomologie in den Vereinigten Staaten* (Berlin: Paul Parey, 1913), 196.

[45] NAUSBE, Box 132, file 'A. Carnegie', A. Carnegie to L.O. Howard, 16 January 1913.

[46] Philip Pauly, 'The Beauty and Menace of the Japanese Cherry Trees', *Isis*, 87 (1), (1996), 51–73; Hae-Gyung Geong, 'Exerting Control: Biology and Bureaucracy in the Development of American Entomology, 1870–1930' (Unpublished doctoral dissertation, University of Wisconsin-Madison, 1999).

age to crops was called 'disease', whether caused by insects or micro-organisms.[47] Moreover, European countries called their plant protection services 'phytopathological organizations', and international meetings dealing with the insect pests and plant diseases were called 'phytopathological' conferences.[48] Howard complained about the tendency to merge economic entomology with plant pathology under one heading, which benefited only the latter.[49]

For Marchal, the duel between plant pathology and entomology had less to do with the defence of two disciplines, than with the survival of French agriculture. The success of the plant protection service of France relied upon having a steady supply of both economic entomologists and plant pathologists. In Howard's Bureau of Entomology, Marchal found the model he sought.[50] The USBE was attractive not only in size – in staff and field stations – but also in its emphasis upon research.[51] Marchal therefore focused 'Les sciences biologiques' on a review of American research. By so doing, he sought to win support for his reforms amongst the leading scientists of France, who alone had sufficient influence to bring about institutional change.

Marchal began his essay with a survey of applied biology. In this, he described the facilities of the Cold Spring Harbor Laboratory, the Carnegie Institution of Washington, DC, and the laboratories of Columbia, Harvard, Johns Hopkins, Berkeley, and Stanford. Acknowledging his indebtedness to Carnegie,[52] Marchal warned his French readers against the temptation to think of Americans as a people so eager to exploit their country's natural resources that they would limit themselves to supporting only those applications of science that paid immediate results: 'Americans

[47] Ralph H. Estey, *Essays on the Early History of Plant Pathology and Mycology in Canada* (Montreal and Kingston: McGill-Queen's University Press, 1994).

[48] Stéphane Castonguay, 'Standardizing Diversity: International Phytopathological Conventions and the Entomological Unification of the World, 1881–1929', in L. Jelecek *et al*. (eds.), *Dealing with Diversity* (Prague: Charles University, Faculty of Science, 2003), 349–351.

[49] NAUSBE, RG-7, E-34, Box 245, File 'Marchal', L.O. Howard to P. Marchal, 26 March 1914. Howard later raised the same point at the American Association of Economic Entomologists annual meeting. L.O. Howard, 'Notes on the Progress of Economic Entomology', *Journal of Economic Entomology*, 8 (1), (1915), 113–119.

[50] NAUSBE, Box 245, File 'Marchal', P. Marchal to L.O. Howard, 7 March 1913.

[51] Already in 1896, he claimed that nowhere in the world was there an organization in applied entomology that could compete with the USA. Paul Marchal, 'L'entomologie appliquée en Europe', *Bulletin de la Société Nationale d'Acclimatation de France (Revue des sciences naturelles et appliquées)*, 43 (13), (1896), 201.

[52] Marchal even wished to have a French equivalent to Andrew Carnegie – 'ce génie bienfaisant des Sciences'. Marchal, *op cit*. note 1, 32.

have entered a new stage of their scientific evolution', he wrote, 'and are devoting an important share of their efforts to the development of pure science, source of major discoveries with enormous impact on economical and social progress'.[53] Marchal then described American laboratories currently engaged in the study of variation, reproduction, development, evolution, and embryology. He informed his readers about American marine laboratories, and also about leading American scientists – including Eugen Davenport, Thomas Morgan, and Jacques Loeb.[54] He highlighted the fact that they worked not only on the selection of breeds and varieties, but rather 'open[ed] new avenues and search[ed] for guiding principles or laws; other researchers [would] have to find the application of such laws and principles'.[55] Even a government department – like the United States Department of Agriculture – was contributing to the solution of conceptual problems in biology. As he pointed out, USDA scientists, working with practical experiments, had materially advanced the understanding of fundamental phenomena, such as parasitism, parthenogenesis, and phagocytosis.[56]

The USDA's agencies were grouped within a central body in shared premises – 'an essential condition to progress' in Marchal's view, which demonstrated the American capacity to resolve tensions between competing services.[57] In highlighting the theme of consensus, Marchal no doubt underplayed Howard's local infighting.[58] But, thanks to the links that Howard had fashioned between his Bureau and the National Museum in Washington, DC, fundamental taxonomic studies were in fact performed in a spirit of cooperation in field laboratories throughout the country.[59]

Marchal then surveyed the various state experiment stations, whose work was funded (and thereby directed) by the Office of

[53] Marchal, *op cit*. note 1, 38. All translations are mine. On American and European marine biology laboratories, see Jane Maienschein, *Transforming Traditions in American Biology. 1880–1915* (Baltimore: Johns Hopkins University Press, 1991).

[54] Marchal, *op cit*. note 1, 38.

[55] *Ibid*., 39.

[56] *Ibid*., 42.

[57] *Ibid*., 51.

[58] The other bureaux that Marchal examined were the BPI, the Bureau of Animal Industry, and the Biological Survey. On the relationship between the BPI and the USBE, see Pauly, *op. cit*. note 46. On the growth of the Forest Service within the Department of Agriculture, see Samuel P. Hays, *Conservation or the Gospel of Efficiency: The Progressive Conservation Movement, 1890–1920* (New York: Atheneum, 1972). On the Biological Survey and the Department of Agriculture, see Keir B. Sterling, *Last of the Naturalists: The Career of C. Hart Merriam* (New York: Arno, 1974).

[59] Marchal, *op cit*. note 1, 64, 56.

Experiment Stations under Alfred C. True.[60] Some state stations resented federal interference, but what impressed Marchal was the commitment of the federal government, and the links that united the Office, the stations, and agricultural education.[61]

Looking to the American agricultural colleges, Marchal found even more role models to follow.[62] In his descriptions of Cornell, Illinois-Urbana, and Berkeley, Marchal conveyed the benefits of linking large universities with agricultural research.[63] Cornell (Howard's alma mater) was 'one of the greatest agricultural colleges and departments of entomology'.[64] Marchal praised the fact that students could work as laboratory assistants in a USBE field laboratory during the summer, and return to the classroom in winter. He was fascinated by the way in which Cornell combined field observation and laboratory life, training biologists to be naturalists as well as researchers.[65] In striking contrast to the INA, Cornell ranked laboratory and fieldwork first, and lectures second – an emphasis made possible by funds from the Office of Experiment Stations.

Everywhere, Marchal saw a unity of practice and theory.[66] At Urbana-Illinois, professors worked both at the University, and in the state experiment station. At Berkeley, applied entomologists, insect taxonomists, and insect morphologists shared the same laboratories, which also 'housed graduate students preparing their *master's degree* or *doctor's degree* [sic]'.[67]

[60] *Ibid*., 229.

[61] On the reactions of local directors to True's centralizing practices, see Margaret W. Rossiter, 'Alfred True on Agricultural Experimentation and Research' in the re-edition of Alfred Charles True, *A History of Agricultural Experimentation and Research in the United States, 1607–1925, including a History of the United States Department of Agriculture* (New York: Arno, 1980), 1–4; Margaret W. Rossiter, 'Graduate Work in the Sciences, 1900–1970', *Agricultural History*, 60 (2), (1986), 37–57.

[62] Marchal, *op. cit*. note 1, 289.

[63] Marchal apologized for not having visited the universities of Kansas, Minnesota, Nebraska, and Ohio, since they were, according to him, also important from the point of view of biological sciences applied to agriculture. *Ibid*., 271.

[64] NAUSBE, Box 245, File 'Marchal', L.O. Howard to P. Marchal, 13 February 1913. On Comstock, see Pamela M. Henson, 'The Comstock Research School in Evolutionary Entomology', *Osiris*, 8 (1993), 159–177.

[65] Marchal, *op. cit*. note 1, 261–262.

[66] *Ibid*., 271.

[67] *Ibid*., 280–281.

Marchal ended his *tour d'horizon* at Harvard. America's oldest university was perhaps an unusual entry in a survey of agricultural institutions. However, Harvard's Bussey Institution gave Marchal yet more evidence of America's success in striking a balance between biology and agriculture. The Bussey Institution, begun as an undergraduate school of husbandry and horticulture, had become a graduate school of applied biology, with an impressive programme of research sponsored in part by a generous grant in 1908 from the Carnegie Institute of Washington.[68]

The choice of Harvard as a concluding, illustrative example was a masterstroke. French scientists were keenly aware of Harvard's contribution to the life sciences. Indeed, only three years after Marchal's visit, an eminent French biologist, Maurice Caullery, would spend a year at Harvard and praise its contribution to knowledge of heredity and reproduction.[69] In his conclusion, Marchal tried to dissipate popular French prejudice against American science. 'Americans', he wrote, 'have proved their ability to marry their large view with the practical bent of their mind, and have avoided drawing clear boundaries between the domains of the scientific spirit and the applied energies'.[70] It was easy to contrast this scene with the French situation. 'Our young people must be able to follow a program', Marchal wrote, 'that accords a large place to applied biological sciences, and, more generally, to the observation of living beings in the natural and agricultural environment. These are the working conditions that will allow biological laboratories to recruit technical staff in a satisfactory manner and with serious guarantees'.[71]

THE DIFFUSION OF 'LES SCIENCES BIOLOGIQUES'

Returning to France in September 1913, Marchal spent the next twenty months promoting his programme. In May 1915, the French government finally established a *Service des Épiphyties* that combined the Ministry of Agriculture's entomological and phytopathological laboratories, and that began to subsidize research in

[68] William Morton Wheeler, 'The Bussey Institution, 1871–1929', in Geoffrey W. Taylor (ed.), *The Development of Harvard University since the Inauguration of President Eliot, 1869–1929* (Cambridge, MA: Harvard University Press, 1930), 508–517.

[69] Caullery, *op. cit.* note 3, 165–168.

[70] Marchal, *op. cit.* note 1, 376.

[71] *Ibid.*, 379.

university science faculties, even though they were administered by the Ministry of Public Instruction.[72] The Ministry of Agriculture was also asked to encourage the INA and the ÉNAs to admit more students, a prospect that inspired Marchal to seek a fresh review of their curricula.[73] In speaking to the Académie d'Agriculture, he described how American universities were training young men in the biological sciences applied to agriculture, whilst noting 'it [was] regrettable that […] France [was] totally lacking in this regard'.[74]

Marchal planned to publish it in the *Annales des épiphyties,* the official Ministry of Agriculture journal that he had founded in 1912, and had edited since. In the event, wartime conditions delayed publication until 1916. Nonetheless, his report appeared at a critical time. Food shortages and the devastation of rich farmlands had forced the French Government to rationalize agricultural production and distribution. Given the situation, '*Les sciences biologiques*' found fertile soil.[75]

Reviewing Marchal's report for *Science*, Howard praised his insistence upon 'the necessity for the introduction into France of such education as our young men get in applied biology in the agricultural colleges and universities like Cornell and Illinois. There is, he points out, in France at the present time no way of getting a scientific education in biological studies as applied to agriculture'.[76] Some years later, Howard's *History of Applied Entomology* (1927) recalled that '[Marchal] had difficulty in finding men to place at the

[72] Fernand David, Ministre de l'Agriculture, 'Décret du 11 mai 1915 portant organisation d'un service de recherches sur les maladies des plantes, sous le nom de Service des épiphyties: Rapport au président de la République française', *Journal officiel de la République française*, (20 May 1915), 4–5; République française. Ministère de l'Agriculture. Direction des Services Sanitaires et Scientifiques et de la Répression des Fraudes, 'Renseignements sur le fonctionnement du Service d'inspection phytopathologique', *Journal officiel de la République française* (15 February 1915), 2.

[73] Paul Marchal, 'Les sciences biologiques appliquées à l'agriculture aux États-Unis', *L'Actualité scientifique*, 6 (January 1917), 185–188; Daniel Claude, 'La lutte contre les ennemis des plantes aux États-Unis', *La Nature*, 2273 (21 April 1917), 241–247; Archives du Muséum National d'Histoire Naturelle, Laboratoire d'Entomologie, Dossier Paul Marchal, 'Notes à l'intention d'un discours prononcé devant l'Académie des Sciences' [1916].

[74] Paul Marchal, 'Lutte contre les ennemis des plantes', *Comptes rendus hebdomadaires de l'Académie d'Agriculture de France*, 2 (1916), 1007–1008.

[75] Robert Delorme and Christine André, *L'État et l'économie: Un essai d'explication de l'évolution de dépenses publiques en France (1870–1980)*, (Paris: Seuil, 1983), 327; Michaël Tracy, *L'État et l'agriculture en Europe occidentale:Crises et réponses au cours d'un siècle* (Paris: Economica, 1986), 195.

[76] L.O. Howard, 'Les sciences biologiques appliquées à l'agriculture et la lutte contre les ennemis des plantes aux États-Unis'. By Dr Paul Marchal. Book Review', *Science*, 45 (1169), (25 May 1917), 504.

head of these "regional entomological stations", as there were practically no men trained in economic entomology in France'.[77]

The resolution of this complex set of problems – institutional and political, regional and national, disciplinary and curricular – was to prove a central challenge not only for wartime governments, but for post-war reconstruction as well. The reforms that eventually took place resulted to a large extent from Marchal's actions, and from a conjuncture of events that led to increased government investment in science overall. The Great War witnessed the extensive mobilization of Allied science, and the creation of new agencies to encourage the application of research in the national interest (for example, the DSIR in Britain, the CSIR in Australia, the NRC in Canada, and the NAS–NRC in the USA). In France also, scientists and industrialists pressed the State to provide permanent funding for research.[78] Within this ambit came the cause of French agriculture.[79]

The Reorganization of Agricultural Research

In 1917, Eugène Tisserand, a Senator of the Republic, a member of the Académie des Sciences, and founder of the INA in 1876 (and its director until 1879), and George Wéry, who had been director of the INA since 1901, presented parallel reports on the state of French agricultural research and education. Basing their conclusions largely upon 'Les sciences biologiques', both recommended a thorough reorganization. Wéry compared the agronomic stations of France, Germany, and America, and, reasoning that the USA, 'our friend of always, … [has] done the most and possibly the best',[80] insisted upon limiting the number of establishments in France, and distributing them regionally, as in the USA.[81] French stations, he found, had focused upon soils and fertilizers, but had neglected more difficult subjects, including genetics (for the breeding of new plant varieties) and *zootechny* (for the feeding of animals).[82] Moreover, Wéry argued, it was obvious that France had too few

[77] Howard, *op. cit.* note 42, 240.

[78] Jean-François Picard, *La république des savants* (Paris: Flammarion, 1988).

[79] A good example can be found in Maurice Caullery's survey, which claimed that 'it [was] a question not of science for the sake of science without reference to application, but of the scientific investigation of practical questions', Caullery, *op. cit.* note 3, 203–204.

[80] Wéry, *op. cit.* note 3, 15–17.

[81] *Ibid.*, 35.

[82] *Ibid.*, 35.

agricultural scientists. He recommended new laboratories and courses, and followed Marchal in suggesting that the close links the Americans had established between experiment stations and agricultural colleges had clearly benefited both.[83]

In another report, delivered in 1917 to the *Société d'Encouragement pour l'Industrie Nationale*,[84] Tisserand argued that the INA should train not only enlightened farmers and agronomists, but also researchers and scientific managers.[85] The Senator blamed the low productivity of regional agronomic stations on their organization and recruitment.[86] France, in his view, needed a station in every region to integrate the disciplines essential to agricultural production.[87] In addition, Tisserand proposed a central research establishment, with laboratories located in or near Paris. As for recruitment, Tisserand argued that the Muséum, the science faculties, the agricultural institutions, and the central agronomic establishment should together be made responsible for generating a flow of new researchers.[88]

In the event, the only immediate organizational changes took place in the field of crop protection, where Marchal reformed the programme of the *Service des Épiphyties* and the manning of its laboratories. Following the end of the war, however, new steps were taken in several directions. First, in keeping with the Government's insistence upon increasing food production, the Ministry of Agriculture in 1920 established an Institut des Recherches Agronomiques (IRA).[89] This new organization united into a single agency more than 80 laboratories and agronomic stations, owned and operated by the Ministry and by the *départements*.[90] Sited at

[83] *Ibid*., 40, 121.

[84] Eugène Tisserand, 'L'enseignement agricole', *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, 127 (1917), 56–69.

[85] *Ibid*., 65.

[86] Tisserand, *op. cit*. note 3, 628.

[87] *Ibid*., 630.

[88] *Ibid*., 629.

[89] Michel Cépède and Gérard Weil, *L'agriculture* (Paris: Presses universitaires de France, 1965), 77; Maurice Agulhon, Gabriel Désert, and Robert Specklin, 'Apogée et crise de la civilisation paysanne de 1789 à 1914', in Georges Duby and Armand Wallon (eds.), *Histoire de la France rurale* (Paris: Seuil, 1977), vol. 3, 581; Adam D. Sheingate, *The Rise of the Agricultural Welfare State: Institutions and Interest Group Power in the United States, France, and Japan* (Princeton: Princeton University Press, 2001), 92; and 'Document parlementaire portant sur la création d'un office central des recherches scientifiques', *Journal officiel de la République française*, 1490 (1 August 1920), 2161–2169.

[90] Albert Demolon, 'Réorganisation des stations agronomiques', *Journal d'agriculture pratique*, New Series, 83 (1919), 92–93; Jean Feytaud, 'L'Office national des recherches scientifiques', *Journal d'agriculture pratique*, 83 (1919), 569.

Versailles, close to Paris, the IRA established a *Centre National de Recherches Agronomiques*, which grouped research laboratories in five disciplines (agronomy and soil biology, physics and meteorology, entomology and parasitology, plant pathology, and plant breeding). Each regional centre received its instructions from Versailles. Second, the administrative centralization of the IRA in Paris was balanced by the establishment of strong regional *Centres de Recherches Agronomiques*, notably in Bordeaux and Clermont Ferrand.[91] Finally, the IRA established a single hiring procedure. Marchal, Wéry, and Tisserand agreed that a centralized organization would be in a better position to train and keep good staff.[92]

A second major reform involved the training of researchers. For a generation since 1889, the Ministry of Agriculture had recruited its scientific staff from among the 'Agros' of the INA. However, many 'Agros' had preferred to go on to one of the Ministry's Écoles d'Application (such as the École des Eaux et Forêts, or the École des Haras), graduation from which led to more influential and lucrative careers. Faced with this situation, the Ministry of Agriculture transformed the INA's third year into a series of *sections d'application*, which were also open to graduates from the ÉNAs and the science faculties. These *sections d'application* involved two years of study. During the first, students attended lectures at the INA; during the second, they studied in a laboratory at one of the IRA's *Centres de Recherches Agronomiques*. Following a competitive examination, they could obtain a permanent position as a *chef de travaux* in an IRA laboratory.[93] *Sections d'application* specialized in the physical and natural sciences, farm management, mutuals, and cooperatives.

In the event, these reforms – extensive as they were – did not solve the problem of research training and staffing. The professors

[91] Other centres were established in Colmar, Antibes, and Montpelier. See Cranney, *op. cit.* note 4, 35.

[92] M. de Monicault, 'Rapport sur le fonctionnement de l'Institut des Recherches Agronomiques en 1922', *Annales de la science agronomique et étrangère*, 30 (1923), 249.

[93] Archives Nationales (France), Centre des Archives Contemporaines (Fontainebleau), Archives de l'Institut National Agronomique (hereafter CACINA), file 3–INA–139, file 'École Nationale Supérieure des Sciences Agronomiques Appliquées, 1918–1920'. Sections d'application. Avis du Conseil de l'Inspection Générale de l'Agriculture, 25 March 1920. The decree leading to the creation of the 'sections d'application' is reprinted in Charmasson *et al., op. cit.* note 11, 456.

of the INA had limited success in attracting the most able students.[94] They also complained that research had suffered from the relocation of INA laboratories to the IRA in Versailles.[95] Indeed, the IRA, whilst lending a new impulse to research, had prompted some INA staff to desert their laboratories for those in Versailles.[96] While some INA professors tried to counterbalance the IRA's centralization, others welcomed the coming of the new IRA laboratories as training facilities. For himself, Marchal came to occupy the best of both worlds. He held the chair of applied zoology at the INA, while at the same time heading the Agricultural Zoology Station at Versailles – from its foundation in 1923 to his retirement in 1933.

In a presidential discourse to the Académie d'Agriculture, delivered in 1930, Marchal surveyed the institutional landscape that his report had done so much to create. Events had moved on, and in the decade since the end of the war, French governments had shown more interest in the encouragement of research. In December 1922, a new Office National des Recherches Scientifiques et Industrielles et des Inventions (the forerunner of the CNRS) was created.[97] In agriculture, Marchal believed that the IRA's *Centres de Recherches Agronomiques* would, under the auspices of the Ministry of Agriculture, instil an 'interdisciplinary' spirit in the next generation of scientists.[98] After nearly twenty years of debate, the Ministry of Agriculture had at last implemented what looked like a solution to the problem of combining education and research.

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[94] 'Rapport sur le fonctionnement de l'Institut National Agronomique: Année scolaire, 1925–1926', *Annales de l'Institut National Agronomique*, 21 (1928), xxi; CACINA, file 3–INA–88, *Réforme de l'enseignement agronomique*, Réorganisation de la section de perfectionnement des sciences appliquées à l'agriculture, Director of the INA [Wéry] to Minister of Agriculture, 5 October 1927; CACINA, file 3–INA–122, *Section de perfectionnement des sciences appliquées à l'agriculture*, 'Exposé. Section de perfectionnement pour les sciences appliquées à l'agriculture', 8 November 1929. On the 'Agros', see *Annuaire de l'Association Amicale des Anciens Élèves de l'Institut National Agronomique: Promotions 1876 à 1935* (Poitiers: Imprimerie Moderne, 1937), 489–493.

[95] CACINA, file 3–INA–68, Registre de procès verbaux des séances du conseil des professeurs, Session of 30 May 1927; file 3–INA–88, *Réforme de l'enseignement agronomique*, Director of the INA [Alquier] to Minister of Agriculture, 13 June 1934; Director of the INA [Alquier] to Minister of Agriculture, 11 February 1935.

[96] *Bulletin mensuel de l'Association Amicale des Anciens Élèves de l'Institut National Agronomique*, 6 (June 1927), 229–239.

[97] Picard, *op. cit.* note 78, 43.

[98] Paul Marchal, 'Discours sur l'enseignement et la recherche en agriculture', *Comptes rendus des séances de l'Académie d'Agriculture de France* (8 January 1930), 266–272.

For Marchal, these changes brought well-deserved satisfaction. However, the story remained short of a happy ending – at least in Marchal's lifetime. No sooner had he retired, that – in April 1934 – the French Government, overwhelmed by the Depression, reduced civil spending. The IRA and its counterpart, the Office National des Recherches Scientifiques et Industrielles et des Inventions, were both disbanded. At the same time, the Ministry of Agriculture absorbed the IRA's laboratories,[99] and ceased to recruit new staff. However, it was clear that any future improvement in agricultural production – an issue that became urgent with the disruption of international trade – rested upon making improved provision for agricultural research. A certain degree of recognition came, at last, in 1942, when the *gouvernement provisoire* of Félix Gouin founded the INRA. This new organization – which continues today – took over the former IRA laboratories, and with them, a great share of responsibility for the future of French agricultural science.[100]

Conclusion

The wartime publication – and post-war implementation – of 'Les sciences biologiques' marked a turning point in the reform of French agriculture. Marchal had seen in the American system certain methods of resolving institutional difficulties that had plagued France for generations. At the same time, he recognized the political importance of insisting upon the values respected by French science. In the event, the circumstances of the Great War modified the terms of the debate, and challenged the government to find a solution. The challenge was, in part, to redirect and coordinate resources and functions divided between two powerful ministries; to encourage a new sensibility in applied research; and to improve the flow of researchers. This, in the short term, at least, the government of France achieved.

To what extent did Marchal and his study influence agricultural research in France? Although the IRA trained few researchers

[99] See Cranney, *op. cit.* note 4, 39–40. See also 'Décret relatif à la transformation des stations et laboratoires relevant de l'Institut des recherches agronomiques', *Journal officiel de la République française* (6 April 1934), 57; and 'Rapport au président de la République sur les offices et établissements demandant la suppression de l'Institut des recherches agronomique', *Journal officiel de la République française*, (31 October 1935). Quoted in Cranney, *op. cit.* note 4, 57.

[100] On the creation of the INRA, see Cranney, *op. cit.* note 4.

before its suppression in 1934,[101] the reforms of which it was part did encourage a new generation of research scientists. Marchal's argument that training should take place in experiment stations and laboratories proved compelling. Using the American model, Marchal and his colleagues framed a policy that bypassed the rigid educational system of France. Of course, the USA was not the only country to show the way. Indeed, the USA may have served less as a role model, and more as a rhetorical device, which Marchal successfully manipulated to legitimate the circumvention of two powerful ministries.[102] Whatever the case, the American example did illuminate key problems facing France. France fell short of reproducing the American system – but then, no one wished to implement any foreign model in its entirety. In agriculture, as in other domains, nations commonly borrow ideas from abroad;[103] but in France, as elsewhere, the act of application preserves a character of its own, with features that resist the impulse – if sometimes also the benefits – of foreign models.

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[101] Between 1928 and 1942, the *Centre National de Recherches Agronomiques* at Versailles trained thirty-three scientists (fifteen in physico-chemistry and eighteen naturalists), thirty of whom pursued a scientific career. Among these, six obtained simultaneously a position in higher education. See Cranney, *op. cit.* note 4, 38.

[102] On the use of the USA as a model for French development after the First World War, see Charles W. Brooks, *America in France's Hopes and Fears, 1890–1920* (New York: Garland, 1987), reprint of a doctoral dissertation (Harvard, 1974).

[103] On industrial reforms, see P. Fridenson, 'Un tournant taylorien de la société française (1904–1918)', *Annales: Histoire, sciences sociales*, 5 (1987), 1031–1060; on academic reforms, see Christophe Charles, 'Ambassadeurs ou chercheurs: Les relations internationales des professeurs de la Sorbonne sous la IIIe République', *Genèses*, 14 (January 1994), 42–62.

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