Agriculture Science and the Rise and Decline of Tobacco Agriculture in the Connecticut River Valley

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Studies examining the early development of agricultural research in the United States have shown that researchers obtained public funding for agricultural experiment stations by entering into a political coalition and by shaping a research agenda which served members of this coalition — particularly agribusiness and commercial farmers. The goal of the stations became "service research," science aimed at meeting the direct needs of the stations' clients. This study examines the implications of service research performed for tobacco agriculture in the Connecticut River Valley.

Agricultural experiment station research played a central role in the development of Connecticut River Valley tobacco agriculture. The station staffs formed close relationships with small-scale farmers, corporate growers, pesticide and fertilizer producers, and cigar manufacturers. However, by the mid-1900s, service for the system's corporate clients and cooperative research ventures between the stations and the corporations generated scientific breakthroughs which bankrupted the researchers' other clients — the independent growers. While continuing to successfully serve the corporations, the station economists and scientists were unable to help the growers. The stations could not serve all clients equally, and the self-enclosed nature of the agricultural research coalition reinforced an intellectual and methodological orthodoxy which proved to be of little value to one segment of the system's clients.

This study examines the research conducted on Connecticut River Valley tobacco agriculture in the twentieth century. From its rise to regional prominence at the turn of the century, to its sharp decline five decades later, tobacco agriculture in the Connecticut River Valley depended on technical and economic services provided by government-funded research. This service research illustrates the function and impact of publicly-funded science in a period of increasingly intimate relations among business, government, and universities.

The nature of agricultural research in the mid-1900s reflected the historical development of formal institutions for agricultural science in the United States. The roots of the research institutions rest in the 1860s and 1870s, with the passage of the first Morrill Act, the establishment of the United States Department of Agriculture (USDA), and the formation of the first, locally-supported, experiment stations. A coalition of researchers, college administrators, politicians, early agribusinessmen, and some farmers forged a political coalition and aggressively asserted the need for stable public funding.[1]

This coalition functioned for the mutual benefit of all the participants. The scientists allied themselves with successful commercial farmers; these growers were most able to adjust their practices as recommended by the researchers. Further, these men were often leaders of farm organizations, with influence in state legislatures and in the United States Congress. The fertilizer manufacturers gained legitimacy through experimental testing of their products and through scientific support for the intensive use of fertilizers. The combined efforts of these groups produced results in 1887, when Congress passed the Hatch Act, authorizing annual appropriations for state agricultural experiment stations

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1. For studies of these efforts, see Margaret W. Rossiter, The Emergence of Agricultural Science: Justus Liebig and the Americans, 1840-1880 (New Haven, 1975); Charles Rosenberg, No Other Gods: On Science and American Social Thought (Baltimore, 1976); and Alfred C. True, A History of Agricultural Experimentation and Research in the United States, 1607-1925 (USDA Miscellaneous Publication number 251, 1937); for a study that challenges the interpretations offered by Rossiter and Rosenberg, see Alan I. Marcus, Agricultural Science and the Quest for Legitimacy (Ames, Iowa, 1985).

affiliated with Land Grant colleges.[2] Two decades later, the Adams Act authorized further funding for the stations. By 1910, the stations were stable sites for science.

These early developments shaped both a political context and a scientific orientation for agricultural research. The research stations were tied into a political network which provided them with powerful allies when legislators determined funding levels, but this confluence of interests also affected research agendas. Science at the stations was service-oriented and utilitarian, aimed at directly benefitting the clients of the station system. This service orientation was true not only for the soil and fertilizer analyses that the stations performed, but also for what the researchers perceived to be "basic research." Experimentation for tobacco agriculture in the Connecticut River Valley provides an example of how the state agricultural experiment station research system worked. By serving the needs of a specific network of clients, the system complemented broader economic trends contributing to increased corporate involvement in American agriculture and to the regional decline of farming in New England.

While native Americans and colonial settlers grew tobacco in the Connecticut River Valley since the seventeenth century, the first major expansion in production occurred in the mid-1800s. Farmers grew two types of tobacco, Maryland Broadleaf and Havana Seed; the cinnamon-colored leaves were popular as cigar wrappers, with the final leaf wrapped around the inner binder and the filler tobacco. Rising consumption of cigars and market demand for Valley leaf led farmers to increase their acreage. But by the late nineteenth century, the cinnamon leaf went out of style, and the lighter-colored, thinner-textured leaf from the Dutch East Indian island of Sumatra supplanted Valley leaf as the preferred wrapper tobacco. Manufacturers continued to use Maryland Broadleaf and Havana Seed as binder tobacco, inside

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2. On the politics of these coalitions, see Charles M. Hardin, Freedom in Agricultural Education (Chicago, 1955), chapter 7; Carroll Pursell, "The Administration of Science in the Department of Agriculture, 1933-1940," Agricultural History XLII (1968): 231-240.

each cigar, but binder was of less value than wrapper and the price of Connecticut River Valley tobacco declined.[3]

Until the turn of the century, most Valley growers grew tobacco as a supplemental cash crop, with little investment in specialized equipment. A continued decline in crop prices might have led to an early demise for tobacco farming in New England. However, several developments in the early 1900s revived tobacco's sagging fortune. While cigar consumption in the United States peaked in 1907 at an average of 265 cigars per adult male per year, prices for cigars and cigar tobacco climbed at a faster rate than the general price index. Farmers had a renewed incentive to produce binder tobacco, and production increased. In addition, farmers began to employ the first specialized tobacco machinery, such as a tobacco-setting machine that facilitated the planting of seedlings.[4] Growers invested in the machines because it saved time and labor, and in a period of rising prices, it made sense to do so. Once farmers bought specialized machinery and built more tobacco sheds, they had to continue in order to justify their investments.

Another development did not merely revive tobacco farming, it rejuvenated Valley tobacco growing. In the late 1890s in Florida, USDA scientists were working with southern tobacco growers to test new Cuban and Sumatran seed strains. The experiments were not wholly successful, but the researchers observed that the plants which were shaded by nearby trees produced leaves of finer texture and better color. The shaded tobacco was almost as fine as the prized Sumatran import. By 1900, a few growers in Florida and southern Georgia were constructing artificial shade.

At the same time, Connecticut River Valley growers persuaded the USDA to conduct a soil survey of the Valley, to determine whether the soil was the reason why New England tobacco could not compete with Sumatran wrapper, even with the

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3. For a comprehensive, if somewhat dated, history of Valley tobacco agriculture, see Elizabeth Ramsey, "The History of Tobacco Production in the Connecticut Valley," Smith College Studies in History XV (1930).

4. R. G. Wheeler, et. al., "Factors in the Outlook for Connecticut Valley Tobacco," Connecticut State Agricultural Experiment Station Bulletin, number 256 (Storrs, 1948), pp. 4 and 15.

high tariff imposed on foreign leaf. In correspondence with their colleagues in the South, the surveyors noted that the Valley soil was very similar to the southern soils in the area where the early shadegrown tobacco was grown. The USDA sent tobacco expert M. L. Floyd north, and in 1900 the federal government planted the first shadegrown tobacco in the Connecticut River Valley, at Poquonock, Connecticut.[5]

Private growers followed the lead of the United States Department of Agriculture, but many of the initial crops failed and most growers claimed that shadegrowing was a passing fad. Again the USDA intervened, testing the seed which the farmers had purchased and showing these skeptical men that many of them had been victims of seed fraud; many of the seeds were not types that the USDA recommended for shadegrowing. The USDA then contracted with a Sunderland grower, guaranteeing a set price and requiring him to itemize the costs of shadegrowing. The crop was successful. The yield was high and of good quality, and the USDA publicized this success. Shadegrown leaf became an accepted segment of the Valley tobacco crop, with production increasing from seventy acres in 1907 to over ten thousand acres in the late 1940s.[6] From its inception, publicly-funded scientific and economic research played a role in Valley tobacco agriculture.

The USDA was not alone in conducting tobacco research in this period, and shadegrown tobacco was the not the only subject. The Connecticut and Massachusetts agricultural experiment stations and the state Departments of Agriculture promoted and sometimes subsidized private tobacco experimentation, beginning in the late 1870s.[7] In 1893, Charles Goessman, a renowned chemist at the Massachusetts Agricultural College and the Massachusetts agricultural experiment station, drew together a group of local growers who, at Goessman's request, formed the Valley Tobacco Experimenters' Association (VTEA), to support and publicize his studies of the effects of different fertilizers on

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5. James W. Callahan, "A Case Study of Labor Inputs and Costs for the Production of Connecticut Valley Shade Grown Tobacco," unpublished master's thesis (University of Massachusetts, Amherst, 1953), pp. 15-17.

6. Callahan, "A Case Study," pp. 5 and 17-22.

7. Ramsey, "History of Tobacco Production," p. 161.

the yield and quality of tobacco crops. Goessman performed chemical analyses of the fertilizers and the plants, and the soil of the VTEA members' farms. Goesman's colleague at the Massachusetts experiment station, George Chapman, studied the tobacco mosaic disease, and concentrated not only on theorizing about the nature of the pathogen, but also on noting agricultural practices which promoted or slowed the spread of the disease.[8]

The emphasis of this early research was utilitarian and promotional. Even George H. Chapman, who studied the pathways of the mosaic disease, directed his work primarily toward how farmers could prevent or slow the spread of the mosaic. Both the USDA and the state stations fostered ties with growers and sought to reinforce their own positions as contributors to agricultural progress.

The 1920s and 1930s were disastrous decades for American agriculture, and Valley tobacco was no exception. Cigar consumption declined steadily from 1910 to 1929, and then dropped sharply during the first years of the Great Depression. In addition, cigar manufacturers introduced machines which required only one binder leaf per cigar, while hand-rolling required two binders. The demand for shadegrown wrapper also declined. Valley wrapper was a relatively high quality leaf and manufacturers used it on high-priced cigars, precisely the product which suffered the steepest decline in consumer demand.[9]

In response to declining prices and demand, growers formed marketing cooperatives, but they could not sustain the costs incurred in withholding the crops from the market. Combined with the manufacturers' attempts to undercut the cooperatives by encouraging non-members to increase production, the cooperatives failed. The value of the outdoor binder crop continued to fall, from $20.2 million to $2.4 million, from 1919 to 1933.[10]

During this period, the manufacturers extended their control over the growers. Using manipulative buying techniques and

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8. Charles E. Goessman, "On Field Experiments with Tobacco in Massachusetts," Massachusetts State Agricultural Experiment Station, Bulletin, number 47 (1897), p. 3; George H. Chapman, "Tobacco Mosaic Disease," Massachusetts State Experiment Station, Bulletin, number 175 (1917).

9. Wheeler, "The Outlook for Valley Tobacco," p. 4.

10. Ibid., pp. 4-5.

playing on the growers' concerns over faltering markets, corporations such as Consolidated Cigar squeezed higher profits out of a declining market, at the expense of the growers. In addition to the overall drop in prices, in the 1930s farmers received almost sixty-six percent less of the final value of a cigar (4.5 cents on the dollar, down from 12 cents).[11] The response by the Massachusetts state experiment station was not dramatic. Work at the station continued to focus on disease control and proper fertilizer use.[12] Agricultural economists did begin to study the economic structure of Valley agricultural production, and they advocated grower participation in the federal production restriction programs.[13] By the late 1930s, both prices and demand stabilized.

This was the foundation for tobacco agriculture in the 1940s and 1950s. Violent market swings had disrupted the tobacco economy for decades. Tobacco growing was highly segmented. Outdoor growers, usually relatively small-scale farmers and often not specialized, grew two types of tobacco — Broadleaf and Havana Seed. Shadegrowers were larger, specialized, and better capitalized. Manufacturers were becoming more influential at the local level, and they bought the tobacco in a decentralized and uncoordinated marketplace. Government agricultural research was involved in the development of agriculture since the nineteenth century, and while research seemed to decline in significance somewhat during the 1930s, its importance would rise once again in the following two decades. During and after World War II, agricultural research played a pivotal role in the changing face of the Connecticut River Valley farmscape.

One area in which the Massachusetts state experiment station concentrated its research efforts was in the development of improved tobacco strains. New plant types had always been important to the Valley, since growers introduced the Maryland Broadleaf in the 1830s. Beginning in 1940, the Massachusetts

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11. Raymond F. Pelissier, "AAA Tobacco Programs in Massachusetts," unpublished master's thesis, Massachusetts Agricultural College, Amherst, 1938, p. 13.

12. See Massachusetts State Experiment Station, Bulletin, number 203 (1921), number 213 (1923), number 276 (1931), and number 346 (1937).

13. Pelissier, "AAA in Massachusetts," pp. 1 and 20-21.

State Experiment Station began a multi-year effort to improve the Havana Seed tobacco. C. V. Kightlinger, employed in the first years of the project through a joint appointment from the Massachusetts State Experiment Station and the USDA's Bureau of Plant Industry, was the primary researcher. He was not attempting to create a new tobacco, but rather was seeking to improve Havana Seed's resistance to Black Root Rot, the single greatest source of damage to the quality and quantity of Valley tobacco. Kightlinger crossed strains noted for resistance with types producing better quality leaves.[14]

There were several reasons for engaging in this work at the Massachusetts station. Kightlinger was a recognized expert in tobacco plant breeding, and coupling disease resistance with improved quality was a project he was well-prepared to investigate. Further, Havana Seed was particularly important in Massachusetts. In the 1940s, eighty-eight percent of the Massachussetts tobacco crop was Havana Seed binder. The manufacturers were also interested in improving Havana Seed, as improved quality would benefit cigar producers as well as growers. Several corporations sponsored Kightlinger's research, providing "seed" money to support the work, and one company provided land which it owned for preliminary testing of the new strains.[15] Kightlinger checked regularly with corporate buyers, to determine if the new strains produced leaves of acceptable quality.

By 1944, Kightlinger was distributing new strains to growers for commercial trials. The results were positive, Kightlinger claimed, for both growers and manufacturers. Havana 211, K1, K2, and T48 produced greater yields per acre without a decline in quality. The new strains required heavier applications of fertilizer, however, making stable or rising leaf prices absolutely necessary for the growers, for if crop prices declined even moderately or if fertilizer prices rose, a cost-price squeeze would have bankrupted the growers. Also, the new strains were

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14. C. V. Kightlinger, "Black Root Rot Resistant Strains of Havana Seed Tobacco for the Connecticut Valley," Massachusetts State Experiment Station, Bulletin, number 432 (1946), p. 3; Massachusetts State Experiment Station, Annual Reports (1940-1960), passim.

15. Kightlinger, "Resistant Strains of Tobacco," p. 7. Kightlinger did not identify the participating corporations.

hybrids, and because the hybrids were sterile, the farmers had to buy their seed for each year's new crop. While the results were not totally positive, Kightlinger did produce work which was desired by the station's clients, both growers and manufacturers.

A majority of the tobacco research fits within the general heading of production research — from seedbed to the curing shed. The range of this research was broad, and it was beyond the capacity of a smaller state agricultural experiment station, such as the one in Massachusetts, to perform. Several other state stations, especially the Connecticut stations, and industrial research laboratories engaged in production studies.[16]

In order to protect the fragile tobacco seedlings, and to gain additional growing time, growers first planted their tobacco in protected seedbeds. The warm, damp, and compact beds were also favorable environments for bacteria, fungi, and weeds. Growers in both Massachusetts and Connecticut requested help in solving this problem. Steam treatment of beds prior to seeding seemed to produce the best results, but the necessary equipment was prohibitively expensive for all but the largest growers. For several years, Massachusetts scientists tested several chemicals and compared the results to steam sterilization. While steam was superior to any chemical, the researchers concluded that some of the chemicals, including chloropicrin, were relatively effective. The scientists went on to determine the best time and appropriate amounts for the chemical applications.[17] At the growers' request, the Massachusetts state experiment stations performed needed tests and provided technical advice.

For diseases, weeds, and pests in the fields, chemical treatment was the preferred method of control advocated by the state agricultural experiment stations. Non-chemical methods were sometimes useful, and programs such as breeding resistant strains did yield results, but these methods were often considered to be inadequate. Breeding was a long and cumbersome project.

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16. Connecticut had two separate experiment stations, the New Haven station which was formed before the Hatch Act, and the Storrs station. Many states which had stations before the passage of the Hatch Act maintained Hatch-funded stations separate from their original stations. However, Connecticut was the only state which did not consolidate its stations.

17. Massachusetts State Experiment Station, Annual Reports, 1940 to 1960, passim.

Other measures, such as crop rotation, were inappropriate; soil requirements differed with alternative crops, or the alternatives did not provide sufficient income, and the capital which growers had placed in tobacco-specific equipment often mandated continual tobacco agriculture. The chemical industry supported this state agricultural experiment station preference. Dow, DuPont, Pfizer, and Rohm and Haas all produced agricultural chemicals for tobacco. The corporations had research laboratories and experimental fields, but they also relied on the state agricultural experiment stations to test their products and, if found to be useful, to report the chemicals' value to the local farmers.[18]

One example of this testing process was the DuPont chemical Fermate, ferric dimethyl dithiocarbamate. Fermate is a fungicide which destroys downy mildew, a problem in the seedbeds and in the fields during rainy seasons. DuPont chemists developed Fermate and tested it extensively. In the mid-1940s, DuPont brought the chemical to stations in both the cigar and cigarette tobacco areas. In 1943, the New Haven station reported that Fermate was useful in battling downy mildew. By 1946, DuPont could state that "Experiment Stations and Extension workers throughout the tobacco growing areas have issued favorable reports." When rumors began to circulate that Fermate reduced the effectiveness of DDT and that the two could not be used together, DuPont again turned to the station staffs. DuPont chemists worked with station scientists to prove that under normal temperatures Fermate did not break down DDT.[19]

The Fermate example was not an isolated case. The chemical corporations kept in close contact with the experiment stations and provided free supplies of their potential products. The two groups often enlisted influential local growers to commercially test the chemicals. The corporate chemists, USDA, and state agricultural experiment station staffs exchanged data and

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18. "Cure for Tobacco Blights," Chemical Week, XXVIII (August 1954): 76.

19. Connecticut Agricultural Station, New Haven, "Report of the Windsor Tobacco Sub-Station," Annual Report (1943), p. 3; "Experiment Stations in Tobacco Growing Sections Recommended 'Fermate' Fungicide to Control Blue Mold (Downy Mildew) in Tobacco Seedbeds," DuPont Agricultural Newsletter, XIV (1946): 30-31.

held frequent conferences to determine the efficacy and the proper application techniques for the chemicals.[20]

The same patterns of testing applied to fertilizers, pesticides, and soil conditioners. Tobacco agriculture required relatively large amounts of fertilizer, often over a ton per acre. The most common fertilizer in the Valley was cottonseed meal, which was extremely expensive. The New Haven station tested ureaform fertilizer, a synthetic compound, as a possible alternative to cottonseed meal. The Massachusetts station studied the feasibility of Wamco, a tradename for processed tankage derived from leather scraps produced in eastern Massachusetts tanneries. The researchers recommended both ureaform and Wamco as partial replacements for the meal, reducing growers' costs without appreciable reductions in yield.[21] Researchers tested and approved a series of pesticides, providing growers with information on the application and specific value of each chemical. Soil conditions ranged from natural products such as peatbog muck to the Monsanto-developed Krilium, which improved the soil's porosity and permeability.[22] The state experiment stations tested these products for the benefit of both the producers and the growers. Both groups were clients, and the stations sought to serve both.

The consequences of state agricultural experiment station testing of industrial farm products were complex. Often required by state legislation, testing of feeds and fertilizers at first, and later pesticides and herbicides, served to draw scientists into a web composed of entangling but seemingly mutually beneficial relationships with industrial manufacturers, and this exerted a powerful influence on the stations' research agendas.

The emphasis on testing and finding directly applicable solutions also shaped the direction of more basic investigations of disease. While the New Haven agricultural experiment station was testing Fermate, its scientists were also studying the pathways of

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20. "Agricultural Chemicals Tested Under Far Western Conditions," Chemical and Engineering News, XXX (1952): 3635.

21. "Chemical Research Aiding Cultivation of Tobacco," Chemical and Engineering News, XXX (1952): 3634; Massachusetts State Experiment Station, Annual Report (1950), pp. 12-13.

22. "Chemical Research," Chemical and Engineering News (1952): 3634; Massachusetts State Experiment Station, Annual Report (1955), p. 14.

the downy mildew pathogen. By 1953, the researchers discovered that the fungus overwintered on old leaf and stem parts in the soil, but then the station discontinued this work; Fermate provided an effective treatment, and research into the nature of the fungus was not therefore a high enough priority to be continued.[23] Another example was the disease which caused tobacco frenching, which resulted in spindly, ragged leaves. In 1949, Linus H. Jones, a botanist with the Massachusetts State Experiment Station, began a series of studies on the possibility of preventing frenching through the application of iron compounds. Jones continued his tests of various ferrous phosphates, until he achieved some relatively satisfactory results. Only after he achieved these results, in 1953, did Jones team up with bacteriologists to try to determine what the frenching factor was.[24] The primary purpose of this basic research at both the New Haven and the Massachusetts stations was not substantially different from the testing of chemicals — producing useful results for the clients of the agricultural research system.

Agricultural engineers and economists engaged in production research, through which they sought to modernize tobacco agriculture and rationalize production; mechanization studies were a cornerstone of these modernizing efforts. While tobacco farmers had employed machines since at least the 1890s, tobacco farming was still relatively backward in the 1950s. Two engineers from North Carolina State College compared the state of mechanization for tobacco in the 1950s to the crude grain reapers of the 1830s.[25]

Mechanization was particularly problematic for Valley growers. Until the mid-1950s, cigar manufacturers placed a premium on both wrapper and binder leaves which had a smooth, thin texture. A large number of thick or torn leaves lowered the value of a grower's crop. Cultivating and harvesting machines handled the leaves in an unacceptably rough manner. The economic segmentation of the Valley tobacco farmers also influenced the direction of mechanization research. The outdoor-

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23. USDA, Office of Experiment Stations, Annual Report (1953), p. 74 .

24. Massachusetts State Experiment Station, Annual Report (1949-1953), passim.

25. William E. Splinter, et. al., "Tobacco Production Needs Mechanization," Society of Automotive Engineers Journal LXIV (1956): 110.

binder growers were small-scale farmers with little access to additional capital. They hired few or no farm laborers, normally relying on their family for field hands. Shadegrowers were quite different. They operated larger farms and had more capital. They regularly hired some permanent and a great number of seasonal laborers. Also, during the Great Depression and World War II, several corporations, particularly Consolidated Cigar and Imperial Tobacco (a Dutch-owned firm), bought a sizable portion of the shadegrown farms, and through contracts they integrated the independent shadegrowers into their businesses.[26]

Because the shadegrowers hired the large majority of farm labor, and because these growers were more financially capable of purchasing new equipment, most mechanization research focused on shadegrown tobacco. This focus severely limited mechanization efforts. Shadegrown tobacco had to be primed; a picker had to take leaves individually from each stalk as each leaf matured. Large cultivators and harvesters could not maneuver around the numerous tent posts holding up the shade cloth. The corporations encouraged the staff of the Massachusetts state experiment station to study these problems, and provided researchers with access to corporate farms in order to examine daily operations. James Callahan, a graduate student at the University of Massachusetts and later an agricultural economist at the school and the Massachusetts station, detailed the operations of one shadegrown farm owned by an unidentified manufacturer, studying the labor costs and the prospects for mechanization. Callahan concluded that increased mechanization was not feasible.[27]

While mechanization yielded few results for shadegrowing, binder tobacco farmers might have benefitted from a combination

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26. "Employment Conditions on Connecticut Tobacco Plantations," Monthly Labor Review LVI (1943): 267. Imperial Tobacco invested heavily in the Valley during the war, as the Dutch lost Sumatra to the Japanese.

27. Callahan, "A Case Study," pp. 77-92. Use of corporate-owned land and facilities was a common practice for Massachusetts station investigators, as the Amherst station was small and had limited physical and financial resources. For other examples of such practices, see, Kightlinger, "Resistant Strains of Tobacco," p. 7; and Claus H. Tameling, "The Curing of Cigar Tobacco with the Use of Kerosene as a Source of Heat, In Comparison with the Use of Liquified Petroleum Gas for the Purpose," unpublished master's thesis, University of Massachusetts, 1953, preface.

of engineering and economic research on their behalf at the Massachusetts station. Growers did not have to prime binder tobacco; they cut the whole stalk and transported it to the curing shed. Until the mid-1950s, developing an appropriate machine was not a research priority. Undertaking that project would have necessitated complementary economic studies examining possible cooperative purchasing and time-sharing programs for farmers who, on their own, could not afford such machines. This work was not done, and mechanization studies for binder tobacco only accelerated in the late 1950s, when other developments, to be noted below, radically transformed the cigar tobacco economy.

While most of the production research, with the exception of some disease investigations, was clearly applied science, the state agricultural experiment stations did engage in basic tobacco research. While the Massachusetts station conducted little work in this area, the New Haven station performed a great deal of basic research, and because there were close ties between the neighboring experiment stations, this division of labor prevented unnecessary duplication of effort. Dr. Hubert B. Vickery, chief biochemist at New Haven during the 1930s and 1940s, was the primary investigator. Vickery's background lay in the study of proteins and amino acids. Beginning in the 1930s, he began a long-term study of cigar tobacco, performing quantitative analyses of the plant's chemical constituents at different stages of growth and during the curing process. He developed analytical methods that remained standard procedures in quantitative analysis into the 1950s.[28]

Vickery's work was of interest to both the growers and the manufacturers. In his chemical analyses, Vickery discovered that fertilizers with a high ammonium content inhibited the production of organic acids in the leaves, thereby reducing the leaves' flavor yet not lowering the plants' yield or textural quality.[29] Farmers could not have empirically determined why their leaves had a bitter taste, leading buyers to lower the price of the crop. The manufacturers maintained close ties to Vickery and other stations' tobacco investigators. After the growers cured the tobacco in

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28. Ray F. Dawson, "Basic Research in Tobacco Chemistry," Journal of Chemical Education XXX (1953): 404.

29. Ibid., p. 405.

their sheds, manufacturers packed and stored the leaves for up to two years. During this time, company workers "sweated" the stored leaves by giving the leaves a series of heat and humidity applications. Until the mid-twentieth century, no one understood the exact nature of the sweatings' effects on tobacco. In the words of one observer, sweating was "a highly skilled and intuitive art." Vickery's findings provided clues to industrial researchers. Walter Frankenburg, head of the research laboratory at the General Cigar Company, was able to gain scientific knowledge concerning the chemical changes involved in sweating. As a result, the company gained more control over the sweating process.[30]

The ties between manufacturers and the station staffs again went beyond simply open channels of scientific discourse. Personnel transferred between government and industrial laboratories, and the stations sometimes performed services for the corporate laboratories. One example of this was a study of the bacterial agents involved in the final sweat. The two investigators, C. O. Jensen and H. B. Parmele, performed the work while employed at the P. Lorillard and Company laboratory in Jersey City, New Jersey. At the time of their article's publication, Jensen had moved to Pennsylvania State College. In addition, the authors acknowledged the assistance of the Agricultural Bacteriology department at the University of Wisconsin, for identifying the bacteria which Jensen and Parmele had isolated in their research.[31]

Scientists and economists also advocated using advances in basic knowledge to rationalize the marketing system for tobacco. Outdoor growers and the few independent shadegrowers not under contract sold their crops in a decentralized market. Growers sold to buyers' agents during private negotiations at each farm, usually during the winter following each harvest. Cigar manufacturing was an oligopoly, and growers did not receive competitive bids. There was no central market with standard price quotations for different grades of leaf. Further, the grading of leaves was itself a highly subjective practice. Buyers would sample the crop to

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30. Ibid., pp. 404-405.

31. C. O. Jensen and H. B. Parmele, "Fermentation of Cigar-Type Tobacco," Industrial and Engineering Chemistry XLII (1950): 519 and 522.

determine its quality, and then quickly offer a price. Growers had to sell the crop at the quoted price, for they had no long-term storage facilities.

At various times, some station researchers proposed possible alternatives to these unregulated market mechanisms. Scientists designed research programs aimed at creating chemical tests which would determine leaf quality, making grading an objective practice. Economists advocated the establishment of centralized marketing systems and standard price quotations. However, such proposals never got off the ground. Manufacturers would have had to implement these programs cooperatively with the farmers, and it was not in the companies' interests to do so. The stations did not direct their efforts toward market rationalization.[32] Thus, while state agricultural experiment station staffs contributed to the standardization of the manufacturing process through studies of the sweating process, markets remained decentralized and the growers' needs went unmet. The ties which bound the staffs to their clients at times seemed to draw them closer to their corporate clients than to the smaller growers.

While marketing received little attention, utilization research became a focus for both government and industrial laboratories. This research involved finding alternative uses for tobacco, and it was spurred on by a combination of bumper crops and wartime shortages of other materials during the early 1940s. The primary focus of these efforts was the extraction of nicotine from the tobacco plants. Chemists took the extracted nicotine and produced two major products, nicotine salts, an effective pesticide made more important by the disruption of pyrethrum imports, and nicotinic acid, part of the vitamin B complex.[33]

Once chemists succeeded in isolating and transforming the nicotine, the problem became duplicating the process on an industrial scale. Researchers at the USDA's Eastern Regional Research Center in Philadelphia constructed the equipment

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32. M. J. Copley, et. al., "Problems in Industrial Utilization of Tobacco," Chemical and Engineering News XX (1942): 1221; Wheeler, "The Outlook for Valley Tobacco," p. 13. Like many other farmers facing arbitrary crop-grading systems, the tobacco growers resented both the grading and the processors/manufacturers, who seemed to profit from the system.

33. Copley, "Industrial Utilization," p. 1220; "Tobacco Does It," Business Week, February 25, 1942, pp. 58-59.

necessary to test the "industrial feasibility" of the simplest extraction method, vacuum steam distillation. Several corporations kept in close contact with the Center's staff, observing the progress and providing consultation. The war ended before the firms started significant production, and the refinement of synthetic pesticides and vitamins rendered obsolete these alternative uses for tobacco.

The utilization research had broader ramifications for Valley tobacco agriculture. The distillation process produced a residue that the USDA staff and chemists at the Kentucky experiment station examined for possible uses. The Kentucky station developed fiberboard, wrapping paper, and carton board from the residue.[34] Like the insecticide and the nicotinic acid, the board and paper were not comercially cost-effective. After the war, however, industrial scientists used the methods and knowledge which the government staffs had developed in this utilization research in a manner that transformed the Connecticut River Valley.

By 1945, the economic situation for Valley tobacco growers was markedly better than it had been for years. Although consumption would never again reach the levels of the early 1900s, a quick jump in consumption led to higher tobacco prices. Tobacco growers were far better off than most farmers in the region. Some economists advised the growers to plant to their present capacity, but not to expand beyond that level by building more sheds or taking out loans.[35] But there were mixed signals coming from station economists, for while some preached cautious optimism, others promoted measures which would have required substantial risk-taking for most growers. These economists told the growers that they would have to expand in order to survive, advocating the clearing and cultivating of all available acres and

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34. "Tobacco Does It," p. 58.

35. Reports on Farm Security Administration loan repayments indicated that rising tobacco prices enabled tobacco growers to meet their payments, while most other local farmers, particularly dairy and poultry farmers, could not. See Massachusetts State Experiment Station, Annual Reports (1942-1946); P. J. Anderson, "Tobacco Outlook for 1945," New England Homestead, April 14, 1945, p. 7.

buying or leasing more land.[36] If crop prices remained high, expansion was a sound practice. Scientific breakthroughs, however, contributed to a precipitous decline in tobacco prices.

During the war, Walter Frankenburg of General Cigar had put the government's utilization research to work for the firm. Using the methods developed for transforming residue into fiberboard and wrapping paper, Frankenburg invented and patented a synthetic cigar binder product. Homogenized Tobacco Leaf (HTL) did have tobacco in it, but it often contained more than fifty percent additives. The tobacco in HTL did not have to be high quality leaf, for the process involved pulverizing the tobacco before processing it.[37] After refining the product, General Cigar put HTL on the market in 1955, and other manufacturers followed.

The results were disastrous for Valley binder growers. Buyers offered less money for the crops, as even high-quality leaves received low-grade prices; high or low-quality, it was all ground to dust. In addition, Homogenized Tobacco Leaf used less tobacco, creating a surplus which further depressed prices. Government price supports were still in place, but the Eisenhower administration had succeeded in lowering parity payments, so that not even the subsidized price was high enough for growers to meet their costs.

Massachusetts researchers reacted to the situation with some attempts to cut the growers' costs, but the effects of their work was like throwing sandbags against a tidal wave. Breeding research continued, as scientists tried to produce higher yielding strains, but the new varieties were more difficult to harvest and cure, and higher yields only aggravated the already serious market glut. Inorganic fertilizers cut costs, but only marginally. Planting seeds directly in the fields cut labor costs, but it also shortened the growing season. The crisis deepened for Valley growers.

Mechanization research did finally produce a low-cost machine for harvesting binder tobacco. An adapted hay-cutter, the machine cut and chopped the whole plant, and did not have to handle the leaves tenderly, as they were headed for Homogenized

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36. David Rozman, "Postwar Readjustments in Massachusetts Agriculture," Massachusetts State Experiment Station, Bulletin, number 430 (1946), p. 1.

37. Dawson, "Basic Research," p. 405.

Tobacco Leaf. The adapted machine might have aided growers if the market had been only slightly or temporarily depressed. But the HTL revolution was so complete that all of the cost-cutting measures combined could not keep most of the growers in tobacco production.[38]

Valley binder production dropped sharply. Economists offered little hope that the outdoor growers could adapt and shift crops, and agricultural experiment stations offered little advice on how to adapt. It was as if the farmers were cancer patients and the economists had diagnosed their illness as terminal and untreatable; the patients did not have long to live, and there was nothing that anyone could do. The economists maintained that the binder tobacco farms were too small, and thus economically marginal. The growers would have to buy or lease more land and obtain new equipment, if they wanted to convert to commercial potato or dairy farming.[39] But the growers could not get financing. The situation was too risky and not lucrative enough for private banks, and the government trough was then relatively dry. The Massachusetts station made no coordinated attempt to facilitate the transfer of this cultivated land in soil-poor New England toward alternative agricultural uses. The cigar corporations bought some of the land and converted it to shadegrown tobacco, but this was a temporary phenomenon, for the Homogenized Tobacco Leaf process soon extended into wrapper tobacco and shadegrowing labor costs were rising steadily; the manufacturers slowly pulled out of the Valley. Real estate developers bought much of the land, and residential cul-de-sacs, shopping centers, and industrial parks sprouted from land where tobacco once grew. In 1961, a new director took charge of the

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38. Richard Southwick and William G. Colby, "Processing of Machine-Harvested Stalk Tobacco," Massachusetts State Experiment Station, Bulletin, number 542 (1964), pp. 1-2; Massachusetts State Experiment Station, Annual Reports (1955-1960).

39. James W. Callahan and B. D. Crossmon, "Production Adjustments on Massachusetts Farms with Tobacco Allotments," Massachusetts State Experiment Station, Bulletin, number 529 (1962), p. 3.

Massachusetts station and discontinued tobacco-related research at the station.[40]

The binder tobacco growers in the Connecticut River Valley were clients of the agricultural research system. As such, they looked to the experiment stations for solutions to some of their problems, and they had supported the continued existence and fiscal merit of the stations. However, these growers were but a small link in an elaborate chain forged by scientists, politicians, and the other clients of the station network, such as the chemical and cigar corporations. Since the stations' beginnings in the mid-1880s, the research staffs had been involved in coalitions that influenced the stations' research agendas. In the case of cigar tobacco, when the Homogenized Tobacco Leaf process undercut the viability of the outdoor growers, the limits of the research agenda prevented the staffs from effectively serving their binder grower clients. The Massachusetts station's ameliorative efforts were limited to some commonly accepted cost-cutting measures, which could not resolve the growers' dilemma. The researchers were unable to venture beyond the theoretical and political framework which had served the stations and most of their clients so well.

The decline of tobacco agriculture in the Connecticut River Valley highlights the internal contradictions associated with client-directed research. The station staffs could not always serve their diverse clientele in an equally beneficial manner. The institution builders in agricultural science built a powerful but self-enclosed support system. Functioning in this system, government agricultural scientists developed research programs and an intellectual perspective which thrived on orthodoxy.

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40. Interview with Dr. A. A. Spielman, former Director of the Massachusetts Agricultural Experiment Station and the Massachusetts Extension Service, and former Dean of the College of Agriculture at the University of Massachusetts, October, 1984.